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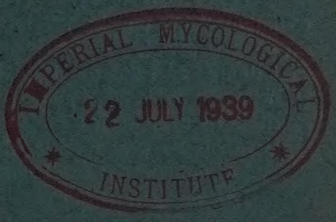

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VOLUME XXIII, № 3

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

N. Weinberg. Sur l'équivalence libre des tresses fermées 215

THÉORIE D'ÉLASTICITÉ

G. Savin. On Some Problems of the Theory of Elasticity of Anisotropic Media 217

P. Koufareff. Définition des tensions dans une plaque elliptique anisotrope 221

PHYSIQUE

W. Fabrikant. Excitation of Atoms in a Gas Discharge 224

A. A. Zaitzev. Temperature of Electrons in Electric Field and Calculation of Townsend's α 229

PHYSIQUE DU GLOBE

P. P. Dobronravine et **I. A. Khvostikov.** Spectre de luminescence nocturne du ciel dans la région ultra-violette 233

CHIMIE

V. I. Goremykin. Hydroxylamine-Thiourea Platinum Compounds 238

V. I. Goremykin and **K. A. Gladyshevskaja.** Oxalates of Ammonium Pyridine Platinum Compounds 242

V. G. Kuznetzov and **E. S. Makarov.** An X-Ray Study of the Structure of Ternary Solid Solutions of Aluminium with Magnesium and Silicon and Their Ageing 245

B. A. Kazansky, A. F. Plate and **E. E. Goldman.** Catalytic Cyclization of 26-Dimethyloctane in the Presence of Platinized Charcoal . 250

M. P. Volarovich and **G. B. Ravich.** Activation Energy and Heat of Melting of Fatty Acids and Triglycerides Calculated from Temperature Relations of Viscosity 252

GÉOCHIMIE

F. V. Chukhrov. Weathering of Jarosites 256

SCIENCE DU SOL Pages

I. D. Sedletzky. Absorbing Complex of Soil—a Paragenetic System of (Colloidal) Minerals 258

GÉNÉTIQUE

A. Shmuck and **Dontcho Kostoff.** Brome-Acenaphthene and Brome-Naphtaline as Agents Inducing Chromosome Doubling in Rye and Wheat 263

E. N. Shmargon. Chromomere Structure of the Chromosome Set of Rye 267

A. A. Prokofieva-Belgovskaja and **V. V. Khvostova.** Distribution of Breaks in the *X*-Chromosome of *Drosophila melanogaster* 270

PHYSIOLOGIE VÉGÉTALE

A. Verner and **A. Tiurina.** Comparative Study of the Requirement of Fungi for Growth Substances B 273

V. A. Novikov and **R. O. Sadovskaja.** Soaking of Cotton Seed in Boric Acid as a Means Going to Satisfy Its Boron Requirement and Increase Salt Resistance 276

SYSTÉMATIQUE DES PLANTES

N. V. Kovalev. Ecological Differentiation of the Cherry Plum *Prunus cerasifera* Ehrh. (s. l. Kov.) 280

N. V. Kovalev. New Species of Plums 284

ENTOMOLOGIE

P. G. Chesnokov. Geographic Variation of Wheats in Their Resistance to Hessian Fly (*Phytophaga destructor* Say) 287

MORPHOLOGIE DES ANIMAUX

N. Disler. Development of Cutaneous Sensory Organs of the Lateral System in *Acipenser stellatus* 292

N. Disler. Structure and Innervation of the Cutaneous Sensory Organs of the Lateral System in *Acipenser stellatus* 295

MÉCANIQUE DU DÉVELOPPEMENT

G. P. Gorbunova. Concerning Inductive Capacity of Medulla Oblongata in Embryos of Amphibians 298

R. J. Braginskaja. Difference in the Rate of Regeneration of Limbs in the Axolotl and Amblystoma as Influenced by Exchange Transplantations of the Skin 302

R. E. Kogan. Inductive Action of Medulla Oblongata on the Body Epithelium of Amphibiae 307

EMBRYOLOGIE DES ANIMAUX

N. A. Manuilova. Changes in Lens-Forming Properties of the Body Epithelium Connected with the Age in *Rana temporaria* and *Rana esculenta* 311

PALÉONTOLOGIE

V. V. Bogachev. Quaternary (Interglacial) Fauna on the Apsheron Peninsula 315

S. V. Semichatova. Stratigraphic Value of Spirifers in Serpukhov Beds of the Lower Carboniferous of the Moscow Basin 319

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MATHÉMATIQUES

SUR L'ÉQUIVALENCE LIBRE DES TRESSES FERMÉES

Par N. WEINBERG

(Présenté par A. N. Kolmogoroff, de l'Académie, le 5. III. 1939)

Cette Note est en rapport avec l'article de A. Markoff «Sur l'équivalence libre des tresses fermées» (1). J'ai réussi de démontrer que l'hypothèse énoncée à la fin de cet article se réalise effectivement et de prouver en même temps que l'opération du type $\mathfrak{T}_5$ * se réduit aux opérations d'autres types. Ainsi nous avons le résultat suivant.

*Pour que deux tresses normales ** soient librement équivalentes, il faut et il suffit que le symbole de l'une de ces tresses soit transformable en symbole de l'autre tresse par une suite d'opérations des types* $\mathfrak{T}_1 - \mathfrak{T}_4$ *et* $\mathfrak{T}_6$.

Voici une esquisse de la démonstration.

Nous commençons par démontrer que si l'opération $\mathfrak{W}_{a,d}^{b,c}$ peut être appliquée à l'enlacement V, alors il existe deux points a' et d' tels que l'on a

$$\mathfrak{W}_{a,d}^{b,c} V = (\mathfrak{U}_{c,d}^{d'})^{-1} (\mathfrak{W}_{d',d}^{a',b})^{-1} \mathfrak{W}_{a,a'}^{c,d'} \mathfrak{U}_{a,b}^{a'} V. \tag{1}$$

Ensuite nous démontrons les deux propositions suivantes.

Deux tresses V et W, normales et librement équivalentes, peuvent être liées par une chaîne $V = V_1, V_2, \ldots, V_m = W$ de tresses normales telle que chaque paire (V_i, V_{i+1}) $(i = 1, \ldots, m-1)$ est liée par une opération du type $\mathfrak{U}$ ou $\mathfrak{W}$.

Soit $W = \mathfrak{W}_{a,d}^{b,c} V$, où V et W sont des tresses normales. Alors il existe des points a', b', c', d' et des tresses normales V' et W' strictement équivalentes («gebunden äquivalent») *** à V et W respectivement, telles que

$$\mathrm{Pr}[a', b', c', d'] \, \mathrm{Pr}[V'] = \mathrm{Pr}[a', d'], \tag{2}$$

$$W' = \mathfrak{W}_{a',d'}^{b',c'} V', \tag{3}$$

où $\mathrm{Pr}M$ désigne la projection de l'ensemble M sur un plan orthogonal à l'axe.

---

* V. l'article mentionné. Le même se rapporte à d'autres notations.

** Une tresse fermée est appelée normale si: 1) chaque droite parallèle à l'axe a des points communs avec deux arêtes de la tresse au plus; 2) le nombre des droites parallèles à l'axe qui ont deux points communs avec la tresse est fini; 3) dans chaque plan contenant l'axe il se trouve au plus une droite de cette nature.

*** On dit que deux tresses fermées V et W sont strictement équivalentes, s'il existe une chaîne $V = V_1, V_2, \ldots, V_{m-1} = W$ de tresses fermées telle que chaque paire (V_i, V_{i+1}) $(i = 1, \ldots m-1)$ est liée par une opération du type $\mathfrak{U}$.

Maintenant numérotons les fils de nos tresses en suivant la direction vers l'axe. Alors on voit aisément qu'à l'opération $\mathfrak{W}_{a',d'}^{b',c'}$ appliquée à la tresse V' et satisfaisant à la condition (1) correspond une opération du type $\mathfrak{T}_6$ appliquée au symbole de V'; et au passage d'une tresse V à une tresse strictement équivalente à V correspond une suite d'opérations des types $\mathfrak{T}_1 - \mathfrak{T}_4$.

Inversement: aux opérations des types $\mathfrak{T}_1 - \mathfrak{T}_4$ correspondent des passages aux tresses strictement équivalentes; et à l'adjonction des opérations du type $\mathfrak{T}_6$ correspond l'adjonction des opérations du type $\mathfrak{W}$ restreintes par la condition (1).

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THEORY OF ELASTICITY

ON SOME PROBLEMS OF THE THEORY OF ELASTICITY OF ANISOTROPIC MEDIA

By G. SAVIN

(Communicated by N. Muskhelishvili, Member of the Academy, 3. III. 1939)

The present paper contains the solutions of some problems of the theory of elasticity of a plane homogeneous anistropic medium. The problems considered below were solved by S. Lekhnitski [1,2] by different methods. So the problem on the distribution of stresses in the neighbourhood of an elliptical hole was solved by him by means of series, whereas his solution of the problem on the distribution of stresses in a half-plane is based on the application of the Fourier integral and was given by him for the case, when the material of the half-plane possesses 3 planes of elastic symmetry.

These problems may be explicitly solved in a very simple way in the general case and by one and the same method, if we apply the well-known formula of Schwarz, by which we can determine the analytical function, if we know the values of its real part on the contour.

The solution of the plane problem of the theory of elasticity for a homogeneous anisotropic medium and given external forces may be reduced to the problem of determination of two analytical functions $\varphi(z_1)$ and $\psi(z_2)$ [1,2], where $z_1 = x + s_1 y$, $z_2 = x + s_2 y$, satisfying the conditions on the contour *:

$$\left.\begin{aligned} 2Re\,[\varphi(z_1) + \psi(z_2)] &= f_1, \\ 2Re\,[s_1\varphi(z_1) + s_2\psi(z_2)] &= f_2, \end{aligned}\right\} \tag{1}$$

where Re denotes the real part, $s_1 = \alpha_1 + i\beta_1$ and $s_2 = \alpha_2 + i\beta_2$ are complex constants, $\beta_1 > 0$, $\beta_2 > 0$ are the roots of the equation

$$\beta_{11}s^4 + 2\beta_{16}s^3 + (2\beta_{12} + \beta_{66})s^2 - 2\beta_{26}s + \beta_{22} = 0, \tag{2}$$

and β_{jk} are constants connected with the elastic constants of the material. The right-hand sides of the equations (1) are given functions on the contour of the considered domain:

$$f_1 = -\int_0^s \overline{Y}_n\,ds + C_1, \quad f_2 = \int_0^s \overline{X}_n\,ds + C_2, \tag{3}$$

where $\overline{X}_n$ and $\overline{Y}_n$ are the projections on the axes of co-ordinates of the external stresses applied to the contour of the considered domain.

* We slightly changed the denotations adopted in the paper referred to above.

The stress components σ_x, σ_y and τ_{xy} depend on the functions $\varphi(z_1$ and $\psi(z_2)$ as follows:

$$\left.\begin{aligned}\sigma_x &= 2Re\,[s_1^2\varphi'(z_1)+s_2^2\psi'(z_2)],\\ \sigma_y &= 2Re\,[\varphi'(z_1)+\psi'(z_2)],\\ \tau_{xy} &= -2Re\,[s_1\varphi'(z_1)+s_2\psi'(z_2)].\end{aligned}\right\} \tag{4}$$

§ 1. Stresses in the Anisotropic Plane with an Elliptical Hole. Suppose that to the contour of an elliptical hole situated in an unbounded anisotropic plate are applied external stresses $\overline{X}_n$ and $\overline{Y}_n$. We make the axes of co-ordinates Ox and Oy coincide with the respective axes of the ellipse.

The contour conditions (1) have the form

$$\left.\begin{aligned}2Re\,[\varphi(z_1)+\psi(z_2)] &= -\int_0^s \overline{Y}_n\,ds+C_1,\\ 2Re\,[s_1\varphi(z_1)+s_2\psi(z_2)] &= \int_0^s \overline{X}_n\,ds+C_2.\end{aligned}\right\} \tag{1.1}$$

Beside the z plane we shall consider also the z_1 and z_2 planes, which arise from it by the affine transformations $x_1=x+\alpha_1 y$, $y_1=\beta_1 y$; $x_2=x+\alpha_2 y$, $y_2=\beta_2 y$, where $z_1=x_1+iy_1$, $z_2=x_2+iy_2$. The given ellipse in the z plane is hereby transformed again into ellipses in the z_1 and the z_2 planes. We map the exterior of the given ellipse and the exteriors of the ellipses in the z_1 and the z_2 planes on the interior of the unit circle by means of the functions:

$$\left.\begin{aligned}z &= \omega(\xi)=\frac{a-b}{2}\,\xi+\frac{a+b}{2}\cdot\frac{1}{\xi},\\ z_1 &= \omega_1(\xi)=\frac{a+is_1b}{2}\,\xi+\frac{a-is_1b}{2}\cdot\frac{1}{\xi},\\ z_2 &= \omega_2(\xi)=\frac{a+is_2b}{2}\,\xi+\frac{a-is_2b}{2}\cdot\frac{1}{\xi},\end{aligned}\right\} \tag{2.1}$$

and find that to the points on the contours of these ellipses corresponding to each other in the affine transformations will correspond one and the same point on the contour of the unit circle.

The contour conditions (1.1) in the transformed domain will have the form:

$$\left.\begin{aligned}2Re\,[\Phi(\sigma)+\Psi(\sigma)] &= f_1(\theta),\\ 2Re\,[s_1\Phi(\sigma)+s_2\Psi(\sigma)] &= f_2(\theta),\end{aligned}\right\} \tag{3.1}$$

where $\Phi(\sigma)=\varphi[\omega_1(\sigma)]$, $\Psi(\sigma)=\psi[\omega_2(\sigma)]$.

Applying to the equations (3.1) Schwarz' formula

$$F(\xi)=\frac{1}{2\pi i}\int_\gamma U(\theta)\,\frac{\sigma+\xi}{\sigma-\xi}\cdot\frac{d\sigma}{\sigma}+i\alpha_0, \tag{4.1}$$

where $U(\theta)$ ist the real part of $F(\xi)$ on the contour of the unit circle, α_0 — a certain real constant, and solving the obtained two equations with respect to the unknown functions $\Phi(\xi)$ and $\Psi(\xi)$, we find

$$\left.\begin{aligned}\Phi(\xi) &= \frac{1}{4\pi(s_1-s_2)}\int_\gamma [s_2 f_1(\theta)-f_2(\theta)]\,\frac{\sigma+\xi}{\sigma-\xi}\cdot\frac{d\sigma}{\sigma},\\ \Psi(\xi) &= -\frac{1}{4\pi(s_1-s_2)}\int_\gamma [s_1 f_1(\theta)-f_2(\theta)]\,\frac{\sigma+\xi}{\sigma-\xi}\cdot\frac{d\sigma}{\sigma}.\end{aligned}\right\} \tag{5.1}$$

Substituting into the functions $\Phi(\xi)$ and $\Psi(\xi)$ instead of ξ its expression through z_1 and z_2 respectively

$$\xi = \omega_1(z_1) = \frac{z_1 - \sqrt{z_1^2 - (a^2 + s_1^2 b^2)}}{a + is_1 b} = \frac{a - is_1 b}{z_1 + \sqrt{z_1^2 - (a^2 + s_1^2 b^2)}} \tag{6.1}$$

into the function $\Phi(\xi)$ and

$$\xi = \omega_2(z_2) = \frac{z_2 - \sqrt{z_2^2 - (a^2 + s_2^2 b^2)}}{a + is_2 b} = \frac{a - is_2 b}{z_2 + \sqrt{z_2^2 - (a^2 + s_2^2 b^2)}} \tag{7.1}$$

into the function $\Psi(\xi)$, we obtain the final form of the functions $\varphi(z_1)$ and $\psi(z_2)$.

Thus, for instance, in the case when the contour of the hole is free from external stresses and the state of stress in the infinity is that of tension of the magnitude p in the direction enclosing the angle α with the axis Ox, the functions $\varphi(z_1)$ and $\psi(z_2)$ will have the form:

$$\left.\begin{aligned} \varphi(z_1) &= -\frac{ip(a - is_1 b)}{4(s_1 - s_2)} \cdot \frac{[b(s_2 \sin 2\alpha + 2\cos^2\alpha) + ia(2s_2 \sin^2\alpha + \sin 2\alpha)]}{z_1 + \sqrt{z_1^2 - (a^2 + s_1^2 b^2)}}, \\ \psi(z_2) &= \frac{ip(a - is_2 b)}{4(s_1 - s_2)} \cdot \frac{[b(s_1 \sin 2\alpha + 2\cos^2\alpha) + ia(2s_1 \sin^2\alpha + \sin 2\alpha)]}{z_2 + \sqrt{z_2^2 - (a^2 + s_2^2 b^2)}}. \end{aligned}\right\} \tag{8.1}$$

§ 2. Solution of the Fundamental Problems for an Anisotropic Half-Plane. Let us direct the axis Ox along the boundary of the half-plane and consider that half-plane, for which $y \geqslant 0$. The contour conditions (1) will have in the present case the form:

$$\left.\begin{aligned} 2Re[\varphi(x) + \psi(x)] &= -\int_0^x \overline{Y}_n \, dx + C_1 = f_1, \\ 2Re[s_1\varphi(x) + s_2\psi(x)] &= \int_0^x \overline{X}_n \, dx + C_2 = f_2. \end{aligned}\right\} \tag{1.2}$$

Schwarz' formula for the half-plane has the form:

$$F(z) = \frac{1}{\pi i} \int_{-\infty}^{+\infty} f(x) \frac{1 + zx}{x - z} \cdot \frac{dx}{1 + x^2} + i\beta_0, \tag{2.2}$$

where $f(x)$ is the real part of $F(z)$ on the boundary of the half-plane and β_0 is a certain real constant.

Applying the formula (2.2) to the contour conditions (1.2) and solving the obtained equations with respect to the unknown functions $\varphi(z_1)$ and $\psi(z_2)$, we find their expressions in the final form:

$$\left.\begin{aligned} \varphi(z_1) &= \frac{i}{2\pi(s_1 - s_2)} \int_{-\infty}^{+\infty} [s_2 f_1(x) - f_2(x)] \frac{1 + z_1 x}{x - z_1} \cdot \frac{dx}{1 + x^2}, \\ \psi(z_2) &= -\frac{i}{2\pi(s_1 - s_2)} \int_{-\infty}^{+\infty} [s_1 f_1(x) - f_2(x)] \frac{1 + z_2 x}{x - z_2} \cdot \frac{dx}{1 + x^2}. \end{aligned}\right\} \tag{3.2}$$

Some examples may be pointed out.

1. Suppose that in the interval $(-a, \ldots a)$ of the boundary of the half-plane are applied uniformly distributed normal stresses P and tangential stresses T. In this case the functions $\varphi(z_1)$ and $\psi(z_2)$ will have the form:

$$\left.\begin{aligned}\varphi(z_1) &= i\,\frac{s_2 P - T}{2\pi(s_1 - s_2)}\left[(z_1 + a)\ln\frac{z_1 - a}{z_1 + a} - 2a\ln(a - z_1)\right],\\ \psi(z_2) &= -i\,\frac{s_1 P - T}{2\pi(s_1 - s_2)}\left[(z_2 + a)\ln\frac{z_2 - a}{z_2 + a} - 2a\ln(a - z_2)\right].\end{aligned}\right\} \tag{4.2}$$

2. Suppose that in the origin to the boundary of the half-plane is applied a concentrated force P encluding with the Ox axis the angle α. The functions $\varphi(z_1)$, and $\psi(z_2)$ have the form

$$\left.\begin{aligned}\varphi(z_1) &= \frac{iP(\cos\alpha + s_2\sin\alpha)}{2\pi(s_1 - s_2)}\ln z_1,\\ \psi(z_2) &= -\frac{iP(\cos\alpha + s_1\sin\alpha)}{2\pi(s_1 - s_2)}\ln z_2.\end{aligned}\right\} \tag{5.2}$$

3. Suppose that in the origin is applied a concentrated normal compressing force P. Putting in the formulae (5.2) $\alpha = +\frac{\pi}{2}$, we easily find from (4) the stress components σ_x, σ_y and τ_{xy}. Let us assume for the sake of simplicity that $s_1 = i\beta_1$, $s_2 = i\beta_2$, i. e. that the material of the half-plane possesses three planes of elastic symmetry. Then we shall have:

$$\left.\begin{aligned}\sigma_x &= -\frac{P\beta_1\beta_2(\beta_1 + \beta_2)}{\pi}\cdot\frac{x^2 y}{(x^2 + \beta_1^2 y^2)(x^2 + \beta_2^2 y^2)},\\ \sigma_y &= -\frac{P\beta_1\beta_2(\beta_1 + \beta_2)}{\pi}\cdot\frac{y^3}{(x^2 + \beta_1^2 y^2)(x^2 + \beta_2^2 y^2)},\\ \tau_{xy} &= -\frac{P\beta_1\beta_2(\beta_1 + \beta_2)}{\pi}\cdot\frac{xy^2}{(x^2 + \beta_1^2 y^2)(x^2 + \beta_2^2 y^2)}.\end{aligned}\right\} \tag{6.2}$$

Putting in the equations (6.2) $\beta_1 = \beta_2 = 1$, we obtain the stress formulae for the case of an isotropic medium.

The second fundamental problem of the theory of elasticity, namely the problem, in which on the contour are given the displacements, may be solved in the explicit form with the same ease with some inconsiderable modifications.

In conclusion I should like to express my profound gratitude to Prof. S. Mikhlin for his valuable suggestions during the preparation of the present paper.

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THÉORIE D'ÉLASTICITÉ

DÉFINITION DES TENSIONS DANS UNE PLAQUE ELLIPTIQUE ANISOTROPE

Par P. KOUFAREFF

(Présenté par S. L. Soboleff, de l'Académie, le 7.III.1939)

En 1936 S. Lekhnitski a trouvé la solution du problème des tensions dans une plaque anisotrope homogène illimitée, affaiblie par une ouverture elliptique (1). D'autre part, N. Mouskhelichvili a proposé la méthode simplifiée de résolution du problème plan de la théorie de l'élasticite dans le cas d'une plaque elliptique isotrope (2). L'application simultanée des méthodes de Lekhnitski et de Mouskhelichvili permet de résoudre le problème dans le cas d'une plaque limitée homogène anisotrope à section elliptique. Dans cette Note j'emploie presque partout les notations adoptées par Lekhnitski.

Bornons-nous à considérer le cas, où les tensions à la limite d'une plaque sont données. L'équation du contour étant donnée sous la forme

$$z = \varphi(\vartheta) = a\cos\vartheta + ib\sin\vartheta \tag{1}$$

le problème se réduit à la définition de deux fonctions $\Phi_1(z_1)$, $\Phi_2(z_2)$ des variables complexes

$$z_1 = x + \mu_1 y, \quad z_2 = x + \mu_2 y, \tag{2}$$

uniformes et régulières pespectivement dans les domaines S_1, S_2, limitées par les ellipses

$$\Gamma_1: \quad z_1 = \varphi_1(\vartheta) = a\cos\vartheta + \mu_1 b\sin\vartheta, \tag{3}$$

$$\Gamma_2: \quad z_2 = \varphi_2(\vartheta) = a\cos\vartheta + \mu_2 b\sin\vartheta \tag{3'}$$

et satisfaisant pour $z_1 = \varphi_1(\vartheta)$, $z_2 = \varphi_2(\vartheta)$ aux conditions

$$2R[\Phi_1(z_1) + \Phi_2(z_2)] = P(\vartheta), \tag{4}$$

$$2R[\mu_1\Phi_1(z_1) + \mu_2\Phi_2(z_2)] = Q(\vartheta) \tag{5}$$

où $P(\vartheta)$, $Q(\vartheta)$ sont des fonctions périodiques données (avec la période 2π) (3).

On peut supposer de plus que dans les constantes complexes

$$\mu_1 = \alpha_1 + i\beta_1, \quad \mu_2 = \alpha_2 + i\beta_2, \tag{6}$$

les parties imaginaires β_1, β_2 soient positives (4):

$$\beta_1 > 0, \quad \beta_2 > 0; \tag{7}$$

Pour résoudre le problème on trace dans le domaine $S_k\,(k=1,2)$ une coupure l_k suivant le segment du grand axe de l'ellipse Γ_k et joignant les points $z_k=c_k$, $z_k=-c_k$, où

$$c_k^2=a^2+\mu_k^2 b^2 \quad (k=1,\ 2). \tag{8}$$

Considérons la fonction

$$z_k(\zeta_k)=\frac{a-i\mu_k b}{2}\,\zeta_k+\frac{a+i\mu_k b}{2}\,\frac{1}{\zeta_k}. \tag{9}$$

Il est facile à vérifier qu'à l'aide de ces fonctions on représente l'anneau

$$B_k:\quad \rho_k\leqslant|\zeta_k|\leqslant 1, \tag{10}$$

où

$$\rho_k=\sqrt{\left|\frac{a+i\mu_k b}{a-i\mu_k b}\right|}, \tag{11}$$

sur le domaine S_k à coupure $l_k[\rho_k<1$ d'après (7)]. Il résulte des formules

$$z_k(e^{i\vartheta_k})=a\cos\vartheta_k+\mu_k b\sin\vartheta_k=\varphi_k(\vartheta_k), \tag{12}$$

$$z_k(\rho_k e^{i\vartheta_k})=c_k\cos(\vartheta_k+\gamma_k), \tag{13}$$

où

$$\gamma_k=\arg\frac{a-i\mu_k b}{c_k}, \tag{14}$$

qu'à l'ellipse Γ_k correspond la circonférence $|\zeta_k|=1$, à la coupure l_k correspond la circonférence $|\zeta_k|=\rho_k$ et aux points

$$\zeta_k'=\rho_k e^{i\vartheta_k},\ \zeta_k''=\rho_k e^{-i(\vartheta_k+2\gamma_k)}$$

correspond le seul point de la coupure:

$$z_k(\zeta_k')=z_k(\zeta_k''). \tag{15}$$

La fonction $\Phi_k(z_k)$ se transforme dans la fonction $F_k(\zeta_k)$, uniforme et régulière dans l'anneau B_k, et par suite elle peut être developpée en série

$$\Phi_k(z_k)=F_k(\zeta_k)=\sum_{m=-\infty}^{\infty}A_{mk}\,\zeta_k^m, \tag{16}$$

où

$$\zeta_k=\frac{z_k+\sqrt{z_k^2-(a^2+\mu_k^2 b^2)}}{a-i\mu_k b}, \tag{17}$$

et où l'on prend pour le radical la valeur satisfaisant les inégalités (10).

Entre les coefficients de cette série on a les relations suivantes

$$A_{-mk}=\left(\frac{a+i\mu_k b}{a-i\mu_k b}\right)^m A_{mk}\quad (m=1,\ 2,\ 3\ldots), \tag{18}$$

résultant des conditions de l'égalité des valeurs des fonctions $F_k(\zeta_k)$ dans les points ζ_k', ζ_k'' [voir (15) et (16)].

Si l'on met les fonctions $\Phi_1(z_1)$, $\Phi_2(z_2)$ sous la forme des séries (16), on doit déterminer les coefficients A_{mk} des conditions frontières (4), (5). Cela est facile à remplir, car on a pour $\zeta_1=\zeta_2=e^{i\vartheta}$ d'après la formule (12)

$$z_k(e^{i\vartheta})=\varphi_k(\vartheta),$$

et par conséquent

$$\Phi_k(\varphi_k(\vartheta)) = \sum_{m=-\infty}^{\infty} A_{mk} e^{im\vartheta}. \tag{19}$$

En développant les fonctions réelles $P(\vartheta)$, $Q(\vartheta)$ en séries de Fourier

$$P(\vartheta) = a_0 + \sum_{m=1}^{\infty} a_m e^{im\vartheta} + \overline{a}_m e^{-im\vartheta}, \tag{20}$$

$$Q(\vartheta) = b_0 + \sum_{m=1}^{\infty} b_m e^{im\vartheta} + \overline{b}_m e^{-im\vartheta}, \tag{21}$$

en substituant ensuite (19), (20), (21) dans les conditions (4), (5), et en égalisant les coefficients de Fourier dans les parties gauche et droite des égalités obtenues, on trouve les équations suivantes:

$$\begin{aligned} A_{m1} + A_{m2} + \overline{A}_{-m1} + \overline{A}_{-m2} &= a_m, \\ \mu_1 A_{m1} + \mu_2 A_{m2} + \overline{\mu}_1 \overline{A}_{-m1} + \overline{\mu}_2 \overline{A}_{-m2} &= b_m. \end{aligned} \tag{22}$$

Ces équations combinées avec les relations (18) déterminent les coefficients A_{mk}.

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PHYSICS

EXCITATION OF ATOMS IN A GAS DISCHARGE

By W. FABRIKANT

(Communicated by S. I. Wawilow, Member of the Academy, 10. III. 1939)

In our previous communications dealing with the excitation of atoms in a gas discharge ([1], [2], [3]) we made the assumption that the concentration of excited atoms or photons on the walls of the discharge tube equalled zero. Such a supposition naturally set a limit to the range of application of the results obtained. When the length of the free path (of atoms or photons) and the radius of the discharge tube are magnitudes of the same order, it becomes clear that more strict boundary conditions have to be introduced. This is particularly true for the treatment of data obtained with the help of luminescent probes ([4]).

In the present paper recourse is made to the more precise boundary conditions used for the solution of diffusion problems connected with the excitation of atoms in a gas discharge.

1. V. de Groot ([5]), while considering the problem of boundary conditions for diffusion problems with a finite length of free path, brought forward, at the very beginning of his article, certain qualitative considerations, providing the possibility of formulating these boundary conditions in a fairly exact manner. This author points to the fact that the flux of particles passing over a surface located at the distance of the free path from the wall should be equal to the number of particles impinging against the wall.

The assumption of such a relationship is virtually equivalent to reducing to zero the flux of particles running from the walls to the volume, a device frequently resorted to in similar optical problems [scattering of light in turbid media ([6])]. V. de Groot made use of the above considerations only for a qualitative evaluation of the concentration of particles at the boundaries.

We intend to show in first place, that if these considerations be imparted with necessary precision, it will not be difficult to obtain the basic relationship given by V. de Groot at the end of his article, which that author obtained with the help of rather long and cumbersome calculations and with the use of integral equations.

V. de Groot considers a linear problem. For the sake of convenience, let us retain his notations. The differential equation of the problem is:

$$k \frac{d^2n}{dx^2} = -a, \tag{1}$$

where k is the coefficient of diffusion equal to λv, λ — length of free path, v — velocity of particles, n — concentration of particles, a — number of particles formed in a unit of time per unit of length. V. de Groot considers a to be independent of x.

If the length of the segment, along which diffusion takes place, is equal to l, the solution of equation (1) will be as follows:

$$n = \frac{a}{2\lambda v}(l-x)x + b, \qquad (2)$$

where b is a constant determined from boundary conditions and equal to the concentration of particles at the boundaries.

The flux of particles travelling towards the boundary due to diffusion and traversing a surface located at the distance of the free path from the boundary is $-k\frac{dn}{dx}$; the number of particles colliding with the boundary is equal to $\frac{nv}{2} - \frac{\lambda v}{2}\frac{dn}{dx}$. According to V. de Groot, we ought simply to consider both these quantities as equal; this, however, fails to be exact, since there is need to take into account also those particles, which arise within the range of the free path; half of these will go to the wall $-\frac{a\lambda}{2}$. Thus, we may write

$$-k\frac{dn}{dx} + \frac{a\lambda}{2} = \frac{nv}{2} - \frac{\lambda v}{2}\frac{dn}{dx} \qquad (3)$$

or

$$a\lambda = nv + \lambda v\frac{dn}{dx}. \qquad (4)$$

In passing from (3) to (4) we have neglected changes in $\frac{dn}{dx}$ over the length of the free path. Neither does V. de Groot make any allowance for this in his more complex solution of the problem.

Relationship (4) is the sought boundary condition. Substituting (2) instead of n into (4) and having determined b, we obtain:

$$n = \frac{a}{2\lambda v}(l-x)x + \frac{l+2\lambda}{v}a. \qquad (5)$$

Relationship (5) is tantamount to the final expression for n obtained in V. de Groot's work.

Thus, condition (3) within certain limits, is found to be equivalent to a more general consideration with the help of an integral equation. It is but natural that with very great lengths of free path ($\lambda \geqslant l$), the stated method can no longer be considered as exact.

2. Let us apply boundary condition analogous with (3) to the problems we are concerned with. In course of our subsequent reasoning we shall make use of the notations we resorted to in our previous communications [1–4].

Just as before, we shall consider the disharge column as an infinite cylinder. Then, in full analogy with (3), we shall have on the walls of the discharge tube:

$$-\frac{1}{3}\lambda\bar{c}\frac{dn_a}{dr} + \frac{1}{3}\alpha_a n q_e \lambda = \frac{n_a\bar{c}}{4} - \frac{\lambda\bar{c}}{6}\frac{dn_a}{dr}, \qquad (6)$$

where n_a is the concentration of excited atoms and photons, $\bar{c}$ — mean velocity of particles, $\alpha_a n$ — number of exciting collisions along the discharge

axis (n is concentration of normal atoms), q_e — distribution of electron concentration along the section of the discharge.

In writing out (6) it is assumed as usual that, due to the passage of the particles being oblique, the thickness of the layer passed on the average without collision is not equal to the length of the free path, but to two thirds of this quantity (7); besides this, we have taken no account of higher degrees of the length of the free path.

3. Let us, first of all, see under what conditions we are empowered to neglect the second member in the left-hand side of equation (6). The ratio of this member to the first member of the right-hand side of equation (6) equals:

$$\delta = \frac{1}{12} \frac{\lambda}{\bar{c}} \frac{\alpha_a n q_e}{n_a}. \qquad (7)$$

For approximate evaluation of δ it is possible to assume that

$$n_a(a) \simeq n_a(0)\, q_e(a). \qquad (8)$$

In the case of weak quenching, the concentration of excited atoms along discharge axis $n_a(0)$ is equal to the number of exciting collisions ($\alpha_a n$) multiplied by diffusional duration of life (3) $\left(\tau_a = \frac{a^2}{D_a \mu^2}\right.$, where a is the radius of the discharge tube and D_a the coefficient of diffusion equal to $\left.\frac{1}{3}\lambda\bar{c}\right)$. Substituting into (7) for n_a its expression, we obtain:

$$\delta \simeq \frac{\mu^2}{4} \frac{\lambda^2}{a^2}. \qquad (9)$$

Parameter μ, with concentration of electrons on the wall equalling zero, equals 2.4 and will be the smaller, the greater is the concentration on the wall; yet, it is liable to vary within a very small range only.

Relationship (9) shows that the magnitude ot δ may be considered as small. As has been shown in one of our previous communications (2,3), any analogy between the diffusion of quanta and atoms is to be observed only with great optical densities. It is not difficult to show that for photons δ may be considered equal to zero with optical density ($\bar{k}a$) by far surpassing $\frac{\mu^2}{2}$.

4. Let us now dwell at some length upon function q_e entering both boundary condition (6) and also the differential equation that we propose to solve in the subsequent (equation 11). As has already been stated (1), according to Schottky's theory, we have:

$$q_e = J_0\left(\mu_1 \frac{r}{a}\right), \qquad (10)$$

where J_0 is Bessel's function, and μ_1 — the first root of Bessel's function.

In the present work we are to substitute μ_1 by parameter μ which is less than μ_1, in so far as the concentration of electrons on the wall often differs even more strongly from zero than the concentration of the particles we are interested in.

There is need to emphasize that discharge conditions of such a kind may be available, under which diffusion conditions have as yet in no way set in for electrons, this being due to the great length of their free path, while such conditions have already set in for atoms or photons.

We shall, however, in all cases make use of relation (10) determining μ from the results of probe measurements, since with respective μ (10) we have a description of the true distribution of electrons given with sufficient accuracy.

Another objection to the use of (10), this time in the realm of higher pressures and current densities, may be brought forward in connexion with the part taken by excited atoms in ionization processes.

Schottky ([8]) failed to allow for cumulative ionization. Klarfeld ([9]) showed that it is just under the conditions of the applicability of Schottky's theory that cumulative ionization of excited atoms is the basic process, involving the formation of charges in the discharge. One may, however, show that the character of the ionization process influences but weakly the appearance of q_e ([10]).

5. In the case of weak quenching, the differential equation for excited atoms will have the following appearance ([1]) ([3]):

$$D_a \frac{d}{dr}\left(r\frac{dn_a}{dr}\right) = -\alpha_a n r J_0\left(\mu\frac{r}{a}\right). \tag{11}$$

This equation is integrated by simple quadratures and, making use of properties of Bessel's functions, we obtain:

$$\frac{n_a(r)}{n_a(a)} = GJ_0\left(\mu\frac{r}{a}\right) + (1-G), \tag{12}$$

where

$$n_a(0) = \frac{\alpha_a n a^2}{D_a \mu^2}\frac{1}{G} \tag{13}$$

$$G = \frac{1-\frac{n_a(a)}{n_a(0)}}{1-J_0(\mu)} \tag{14}$$

and $\frac{n_a(a)}{n_a(0)}$ are determined from boundary condition (6):

$$\frac{n_a(a)}{n_a(0)} = \frac{p}{1+p}, \tag{15}$$

where

$$p = \frac{2\lambda}{3a}\frac{\mu J_1(\mu)}{1-J_0(\mu)} \simeq \frac{4}{3}\frac{\lambda}{a}\left[1-\left(\frac{\mu}{4}\right)^2\right]. \tag{16}$$

In (16) we neglected δ as compared with unity; if we are now to take δ into account, factor $\frac{1}{1-\delta}$ will appear in p. Approximate expression for p is obtained with sufficient exactitude for $\mu \leqslant 2.4$ (with the help of development into series).

From (15) and (16) it follows that the ratio of concentration on wall to maximum is simply close to $\frac{\lambda}{a}$. In formula (13), in contradistinction to the usual expression corresponding to distribution according to Bessel's function $\left(\frac{\alpha_a n a^2}{D_a \mu^2}\right)$, there appears for $n_a(0)$ a new factor $\frac{1}{G}$, which differs the more from unity, the more the distribution of atoms differs from the distribution of electrons [it should be borne in mind that $J_0(\mu) = \frac{n_e(a)}{n_e(0)}$].

6. In the case of very strong quenching the differential equation for exciting atoms assumes the following asymptotic appearance ([3]):

$$y_a'' + \frac{1}{t} y_a' - y_a = -1, \tag{17}$$

where y_a is the «reduced» concentration of excited atoms, $t = \frac{r}{a}\sqrt{B_a}$, $B_a = \mu^2 \beta_a \tau_a$, β_a — is the probability of quenching.

The solution of equation (17) with boundary condition (6) and again neglecting δ is as follows:

$$y_a(r) = 1 - \frac{I_0\left(\sqrt{B_a}\frac{r}{a}\right)}{I_0(\sqrt{B_a}) + \frac{2}{3}\frac{\lambda}{a}\sqrt{B_a}\, I_1(\sqrt{B_a})}, \tag{18}$$

I_0 and I_1 are Bessel's functions from a purely imagina argument. This solution differs from the one formerly obtained ([1,3]) by the appearance of a second member in the denominator of the fraction.

With sufficiently great $\sqrt{B_a}$ it is possible to postulate $I_1(\sqrt{B_a})$ as equal to $I_0(\sqrt{B_a})$ ([11]); then

$$y_a(a) = \frac{1}{1 + \frac{3}{2}\frac{a}{\lambda}\frac{1}{\sqrt{B_a}}}. \tag{19}$$

If we avail ourselves of expressions for B_r and τ_r (index r refers to radiation) and also make use of the coefficient of diffusion for photons, equal to $\frac{1}{3}\frac{\lambda^2}{\tau}$, where τ is the life of an isolated excited atom, then we obtain:

$$y_a(a) = \frac{1}{1 + \frac{3}{2}\sqrt{3\tau\beta_a}}. \tag{20}$$

Since $\tau\beta_a$ is usually two or three orders less than unity ($\tau \ll \tau_a$), the second member in the numerator will be much greater than unity and:

$$y_a(a) \simeq \frac{2}{3}\sqrt{3\tau\beta_a}. \tag{21}$$

From (18) and (21) it follows that the corrections introduced by imparting greater precision to boundary conditions are essential in the case of strong quenching only for points lying close to the walls of the discharge tube.

An experimental check-up on the relationships provided in the present paper is being carried out at present in our laboratory with the help of luminescent probes.

The question as to the applicability of boundary condition (6) to the theory of the action of the probes themselves will be discussed separately.

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PHYSICS

TEMPERATURE OF ELECTRONS IN ELECTRIC FIELD AND CALCULATION OF TOWNSEND'S α

By A. A. ZAITZEV

(Communicated by S. I. Wawilow, Member of the Academy, 10. III. 1939)

The stationary velocity distribution of electrons diffusing through a gas has been solved by Druyvesteyn (1) for the case of elastic as well as non-elastic collisions between the electrons and the gas atoms. When employed in calculating the ionization coefficient α of Townsend for neon, Druyvesteyn's solution yields values consistent with the experiment. Later on, it was attempted by Moralev (2) and Glotov (3) to calculate α, adopting a priori that in a discharge due to external agent Maxwell distribution is available. This implies that the motion of electrons on Townsend's discharge, with low current density, is identified with their motion in the positive column of a self-sustained discharge, where the current density is so high that the interactions between the electrons mutually and between the electrons and positive ions play essential part in velocity distribution. We are not entitled, however, to such an identification without further inquiry, and the question discussed below is whether Maxwell distribution is applicable to calculation of Townsend's α.

If Maxwell distribution is adopted, the calculation of Townsend's α differs by nothing from the calculation of ionization coefficient in the positive column, which has been effected by several authors and for various cases (4,5). But the usual method in their calculation was to apply the measured values of electron temperature. Our purpose, however, requires that the temperature of the electrons moving in a homogeneous electric field be calculated theoretically from the atomic constants. The problem is interesting in itself, since with the positive column of a glow discharge we actually have a case of electrons moving in a homogeneous electric field, where their velocity solution obeys Maxwell law.

The equation to begin with in calculating T_e is that of energy balance for an electron, when the latter is in stationary motion in field E:

$$evE = A_i + A_e + A_{el} + A_c, \qquad (1)$$

where e is charge of the electron; v is mean directed velocity of the electron; A_i, A_e and A_{el} are energies lost by the electron in unit time on ionization, excitation or elastic collision respectively; A_c, the last term on the right-hand side of the equation, is energy lost in acceleration of electrons ($A_c = N_i p e V_0$; $N_i p$ is number of ionization per second made by an electron when the pressure of gas equals p; V_0 is electron temperature in volts). The

mean directed velocity is expressed through electron mobility according to the formula (6)

$$v = aE = 0.75 \frac{e\lambda_e}{m_e \omega} E,$$

where m_e is mass of an electron; λ_e is mean free path of the electrons; ω is their average temperature velocity.

By means of some transformations we get from (1)

$$\sqrt{V_0}\left(\frac{A_i + A_e + A_{el} + A_c}{p}\right) = 0.75\sqrt{\frac{3\pi e^3}{16m}} \frac{\lambda_0}{p^2} E^2 \qquad (2)$$

where λ_0 is mean free path of the electrons at $p=1$ mm Hg. Experiments have shown that the probability for a gas atom to be excited and ionized depends on the energy available in the electron when it is impinging upon the atom (7,8). The probability for an electron to possess more or less energy is a function of temperature T_e. The left member of equation (2) is therefore a function of electron temperature, while the right member is a function of $\frac{E}{p}$ for every gas given. Let us consider the case of neon. Suppose this gas to have one ionization potential and one excitation potential (1). The functions

$$B_i = d\frac{c^2 - c_i^2}{c_i^2} \quad \text{and} \quad B_e = b\frac{c^2 - c_k^2}{c_k^2}$$

present a fair way to express the experimentally established dependence of ionization and excitation upon electron energy (1). It will be obvious that

$$A_i = N_i peV_i,\ A_e = N_e peV_e,\ A_c = N_i peV_0, \qquad (3)$$

where

$$N_i = \int_{c_i}^{\infty} \frac{c}{\lambda_0} B_i \varphi(c)\, dc \quad \text{and} \quad N_e = \int_{c_e}^{\infty} \frac{c}{\lambda_0} B_e \varphi(c)\, dc.$$

Here $\varphi(c)$ is Maxwell function of velocity distribution. The energy lost by an electron on its elastic collisions with the gas atoms is given by the equation (2):

$$A_{el} = 2.66 \frac{m}{M}\left(1 - \frac{V_a}{V_0}\right)\bar{\varepsilon}\frac{\omega}{\lambda}. \qquad (4)$$

Here M is mass of the gas atom; V_a is temperature of the gas; $\bar{\varepsilon}$ is average energy of the electron. Equations (3) and (4) when solved with (2) give

$$\frac{4}{\sqrt{\pi}}\sqrt{\frac{e^3}{3m}}\left\{V_i V_0 d\left(1 + \frac{4}{3}\frac{V_0}{V_i}\right)e^{-\frac{3}{2}\frac{V_i}{V_0}} + \right.$$
$$+\sqrt{\frac{9}{4}}\, b\, \frac{V_e}{V_k}\left[V_e(V_e - V_k) + \frac{2}{3}V_0\left(\frac{4}{3}V_0 + 2V_e - V_k\right)\right]e^{-\frac{3}{2}\frac{V_e}{V_0}} +$$
$$\left. + 2.66\frac{m}{M}\left(1 - \frac{V_a}{V_0}\right)\sqrt{V_0^4}\right\} = 0.75\sqrt{\frac{3}{16}\frac{\pi e^3}{m}}\lambda_0^2 \frac{E^2}{p^2}. \qquad (5)$$

Equation (5) admits of a graphic solution. In this way values of electron temperature may be found which will correspond to any given $\frac{E}{p}$. And in turn, to find those values $\frac{E}{p}$, which correspond to some fixed values

T_e, is a matter of simple calculation. Curve *1* in Fig. 1 brings out the dependence of T_e upon $\frac{E}{p}$ thus established. The crosses mark the data obtained by Druyvesteyn ([9]) on measuring electron temperature in the positive column for the case of neon, while the data of Seeliger and Hirchert are marked with circles ([10]). The conclusion to be drawn from comparing the calculated values of electron temperature with the measured ones is that they agree satisfactorily with each other. The dependence of the mean free path of the electrons upon their velocity (Ramsauer effect), which is observable in neon at low velocities, was approximately taken into account and λ_0 in the mobility equation of Langevin was substituted with those of its values which corresponded to the values of electron temperature([11]) arbitrarily fixed.

Electron temperature T_e as a function of $\frac{E}{p}$ was also calculated by Mirdel([12]) for the positive column in neon, argon and helium. But in the equation of energy balance he has failed to consider the energy lost in acceleration of ele-

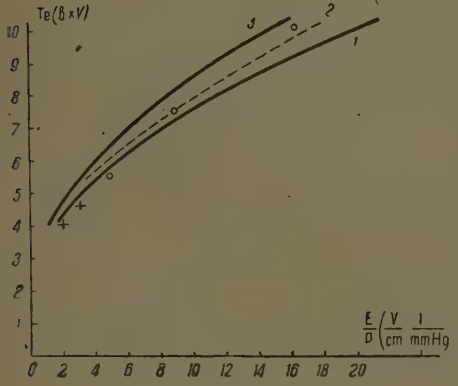

Fig. 1.

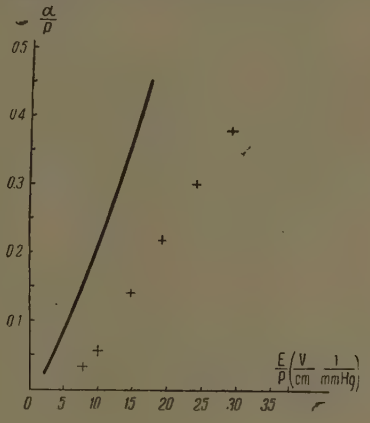

Fig. 2.

ctrons produced by ionization. Furthermore he has introduced one common level for excitation and ionization, and has been considering one general probability for non-elastic collisions, whether exciting or ionizing, to take place between the electrons and the gas atoms. It is indeed a less accurate method of treating the question than to introduce the probability of excitation and that of ionization as separate functions. The values of T_e Mirdel has obtained by his method of calculating the energy loss exceed the result of our calculation, albeit inconsiderably. Curve *3* in Fig. 1 represents the dependence of T_e upon $\frac{E}{p}$ provided that term A_c is discarded from equation (1) and that our results are modified according to Mirdel's use of one function for the probability of non-elastic collisions. The coefficient 0.75 in the equation of electron mobility bas been substituted with 1 by Mirdel and this also goes to increase the values of T_e so far as $\frac{E}{p}$ is given. Curve *2* in Fig. 1 represents the dependence of T_e upon $\frac{E}{p}$, when the coefficient 0.75 in Langevin's formula of mobility is replaced by 1.

Equation (4) gives the number of ionizations N_i made by an electron in unit time at $p=1$ mm Hg. N_i being known, it is easy to get the number of ionizations made by an electron while it was travelling a distance

of 1 cm along the field or what is called Townsend's α. In fact, it is obvious that

$$\alpha = \frac{N_i p}{v} \quad \text{or} \quad \frac{\alpha}{p} = \frac{N_i}{v}.$$

In Fig. 2 the dependence of $\frac{\alpha}{p}$ upon $\frac{E}{p}$ is brought out. The solid curve (calculated) shows that with Maxwell distribution adopted the values of α notably exceed the experimental values (crosses) (1).

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PHYSIQUE DU GLOBE

SPECTRE DE LUMINESCENCE NOCTURNE DU CIEL DANS LA RÉGION ULTRA-VIOLETTE

Par P. P. DOBRONRAVINE et I. A. KHVOSTIKOV

(Présenté par O. J. Schmidt, de l'Académie, le 27.II. 1939)

Au moyen de puissants spectrographes (f : 1.0 et f : 0.58) à l'optique en quartz-fluorite-silvine, produits grâce à l'initiative de S. I. Wawilow par l'Institut de l'Optique à Leningrade, on a photographié au cours de plusieurs années les spectres ultra-violets de luminescence du ciel nocturne. Les photographies étaient prises au sud de l'URSS (mont Elbrouz, au Caucase, et à l'observatoire astronomique à Siméise, Crimée).

On sait qu'à côté de plusieurs raies d'émission faibles les spectrogrammes ont toujours le fond continu. M. Dufet encore en 1925 a découvert sur ce fond un grand nombre de raies d'absorption, coïncidant avec les raies de Frauenhofer. Or, il est connu, que l'intensité de la lumière dispersée par l'atmosphère terrestre décroît rapidement vers les ondes courtes, à partir de la borne violette du spectre visible. Pour cela, d'après la considération purement visuelle des spectrogrammes, on garde l'impression que le fond ultra-violet dans le spectre de la luminescence nocturne du ciel possède une intensité plus grande que l'on pourrait attendre. Pour éclaircir cette question nous avons effectué les expériences consistant dans la comparaison directe photométrique de la répartition de l'énergie dans la partie ultra-violette du spectre de la luminescence nocturne du ciel et de la lumière disperse du ciel du jour. Les expériences ont été effectuées en été 1937 et 1938, à l'observatoire astronomique de Siméise, au moyen d'un spectrographe f : 0.58.

Ce spectrographe a un prisme de silvine et les objectifs achromatiques en quartz-fluorite. La chambre est munie d'un objectif de Rayton à l'ouverture de 42 mm. Le prisme de 30° en silvine, combiné avec une chambre ayant une distance focale extrêmement courte (f=25 mm), donne évidemment une dispersion très petite. Pour cela l'appareil en question ne convient pas à l'étude des détails du spectre. Cependant la puissance énorme du spectrographe le rend utilisable pour la résolution du problème cité plus haut, car de bons clichés peuvent être obtenus avec des pauses pas trop grandes. Pour photographier le ciel on a employé les plaques Impérial-1200, la fente étant de 0.05 mm (ce qui correspond à la largeur de l'image de la fente sur la plaque égale à 0.007 mm). On a photographié le ciel dans la région de l'étoile polaire. La pose variait de 8 à 32 heures, ce qui permettait de choisir ensuite les photographies à noirceur voulue. Cinq photographies du ciel nocturne ont été obtenues au cours des expériences préliminaires en 1937. Il est plus

difficile d'obtenir les photographies du spectre du ciel du jour dans les conditions quelque peu semblables à celles des photographies des spectres du ciel nocturne, car il est nécessaire d'affaiblir énormement la lumière sans changer sa composition spectrale. Nous avons rejeté les méthodes basées sur l'absorption, car il est difficile de réaliser la neutralité de l'absorption, et nous nous sommes arrêtés sur la méthode géométrique de l'affaiblissement au moyen d'une petite ouverture (surface de $^1/_4$ mm^2) placée devant la fente au bout d'un tuyau étroit à la distance de 30 cm, environ, de la fente. Cela affaiblissait beaucoup la lumière, mais la puissance du spectrographe était si grande que même dans ce cas on n'arrivait pas à donner une pose supérieure à 8 sec. Cela causait des différences des conditions pour les photographies prises le jour et la nuit, d'abord en largeur du faisceau, et par conséquent, en parties utilisées des objectifs de la chambre et du collimateur, et surtout en durée de l'exposition. Donc, la comparaison des clichés ne pouvait servir qu'à en tirer des conclusions hypothétiques.

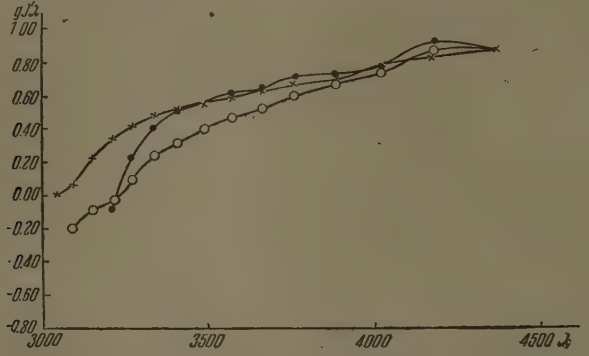

Fig. 1, *A*. × — nuit, ○ — demi-jour, ● — jour.

Ont été prises de plus les photographies des étoiles α Lyrae et α Cygni, que l'on se proposait de considérer comme sources d'une petite intensité à une répartition connue de l'énergie; dans ce but le spectrographe a été fixé sur une lunette astronomique de 3″, ayant des pieds parallactiques et munie d'un mouvement d'horloge. On a fait aussi deux photographies (de α Cygni et du ciel) avec une fente à gradins (pour tracer la caractéristique des plaques) ainsi que les photographies de α Cygni et du ciel parallèlement au spectre de Hg, afin de pouvoir comparer les longueurs d'ondes.

L'examen des photographies prises en été 1937 et des microphotogrammes, qui en ont été obtenus, a montré que l'hypothèse sur un certain excès des rayons ultra-violets dans la lumière du ciel nocturne, relativement à la lumière du ciel du jour, est probablement juste, mais toutefois nous nous gardons de faire la comparaison définitive.

Les observations ont été répetées en juillet—septembre 1938; elles ont été complétées de photographies prises au demi-jour: après le coucher et avant le lever du soleil. Ces photographies ont, par rapport à celles prises le jour, l'avantage, car elles permettent de mieux niveler les durés des expositions avec celles de photographies nocturnes, et cela sans avoir recours au diaphragme.

On obtenait les échelles photométriques sur un spectrographe du telescope de 1 m à l'observatoire de Siméise, la fente étant à gradins. Afin d'augmenter la précision photométrique, les photographies étaient prises par séries. Une série était composée de quelques photographies du ciel du jour, nocturne et crépusculaire et des échelles photométriques.

№ du point	λ (approx) 0—0 mμ	Logarithmes lg I'_λ									Différences des logarithmes Δ lg I_λ							
		Nuit			Demi-jour			Jour			Nuit—demi-jour				Nuit—Jour			
		A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*	moyenne	*A*	*B*	*C*	moyenne (*B* et *C*)
0	436	0.89	0.61	0.67	0.89	0.61	0.65	0.89	0.65	0.66	0.00	0.00	+0.02	+0.01	0.00	−0.04	+0.01	−.02
1	417	.86	.60	.59	.87	.60	.62	.93	.61	.64	−.01	.00	− .03	− .01	−.07	− .01	− .05	−.03
2	402	.78	.54	.56	.76	.54	.54	.77	.58	.59	+.02	.00	+ .02	+ .01	+.01	− .04	− .03	−.04
3	388	.71	.49	.46	.67	.42	.43	.72	.46	.36	+.04	+.07	.03	.05	−.01	+ .03	+ .10	+.06
4	376	.67	.46	.44	.60	.39	.36	.71	.40	.34	.07	.07	.08	.07	−.04	.06	.10	.08
5	366	.62	.42	.38	.50	.34	.31	.64	.33	.29	.12	.08	.07	.09	−.02	.09	.09	.09
6	357	.59	.40	.36	.47	.26	.24	.61	.26	.21	.12	.14	.12	.13	−.02	.14	.15	.14
7	348	.56	.35	.29	.40	.17	.14	.55	.20	.17	.16	.18	.15	.16	+.01	.15	.12	.14
8	340	.52	.32	.23	.31	.05	−.02	.52	.17	.10	.21	.27	.25	.24	.00	.15	.13	.14
9	334	.48	.27	.19	.24	−.01	−.24	.40	.10	−.01	.24	.28	.43	.32	+.08	.17	.20	.18
10	327	.42	.21	.10	.10	−.15	−.40	.21	−.11	−.25	.32	.36	.50	.39	+.21	.32	.35	.34
11	321	.34	.11	−.04	−.04	−.33	−.51	−.07	−.28	−.52	.38	.44	.47	.43	+.41	.39	.48	.44
12	315	.22	.04	−.16	−.10	−.41	−.68	—	−.59	—	(.32)	.45	.52	.48	—	.63	—	.63
13	310	.06	−.04	−.32	−.20	−.55	—	—	—	—	(.26)	.51	—	.51	—	—	—	—
14	304	—	−.12	−.45	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(15)	—	—	—	−.55	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(16)	—	—	—	−.61	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Toutes les photographies d'une série étaient prises sur les parties d'une même plaque découpée (13×18 Impérial-1200) et toutes étaient développées en même temps. En tout on a pris trois séries de photographies (A,B,C) dont 8 nocturnes, 10 crépusculaires, 12 spectres du jour et 7 photographies des échelles. Plus tard ces photographies ont été photométrées sur un microphotomètre de Moll avec un agrandissement de 50 fois.

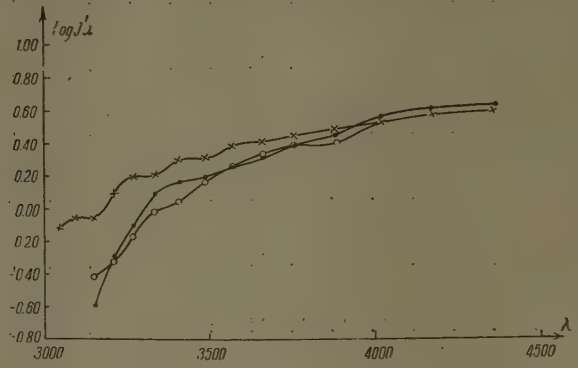

Fig. 1, B. × — nuit, ○ — demi-jour, ● — jour.

Le passage de la noirceur en intensité s'effectuait par un moyen mécanique à l'aide d'un microphotographe, appartenant à l'Observatoire Astronomique Principal de l'Académie des Sciences de l'URSS. L'appareil donnait un graphique dont les abscisses étaient les longueurs du spectre, l'axe des ordonnées donnait les logarithmes du produit de l'intensité par la sensibilité de la plaque pour la longueur d'onde donnée ($\log I'_\lambda = \log I_\lambda + \log S_\lambda$).

Sur les mêmes graphiques on donnait les repères des longueurs d'ondes. L'étude se faisait à partir du repère de mercure $\lambda = 4358$ Å dans le sens des

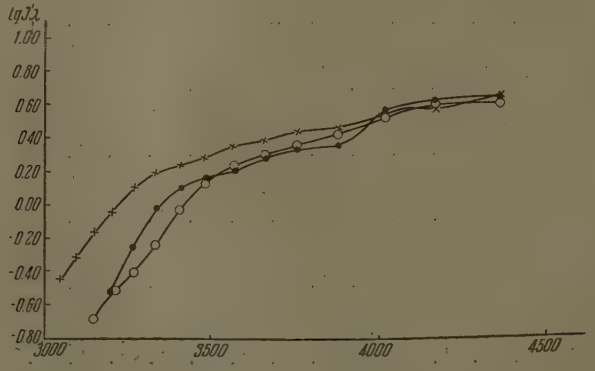

Fig. 1, C. × — nuit, ○ — demi-jour, ● — jour.

longueurs d'ondes plus courtes. Pour chaque série des photographies du jour, nocturnes et crépusculaires, les valeurs de $\log I'_\lambda$ étaient réduites de façon à ce qu'on puisse conventionnellement niveler les intensités au voisinage de $\lambda = 4358$ Å. Les résultats de cette étude sont donnés dans la table. Pour la représentation graphique de ces résultats—voir fig. 1.

En examinant la table et la fig. 1, on arrive à la conclusion que les courbes des photographies du jour et crépusculaires des séries B et C pratique-

ment coïncident, ce qui justifie l'emploi d'une petite ouverture devant la fente du spectrographe dans le but d'affaiblissement. Les courbes des photographies nocturnes dans la région ultra-violette sont situées nettement plus haut. Dans la série *A* la courbe des photographies crépusculaires coïncide avec les courbes correspondantes des séries *B* et *C*, tandis que la courbe des photographies du jour s'en distingue quelque peu. Cela peut s'expliquer par l'effet d'une erreur d'observation, car la petite ouverture devant la fente était montée, au cours des observations du jour, peu heureusement, ce qui déformait le spectre. Ce défaut a été éliminé au cours des prises des séries *B* et *C*.

Il est intéressant de considérer: 1) les moyennes des différences «nuit moins crépuscule» de toutes les séries et 2) des différences «nuit moins jour» des séries *B* et *C*. La représentation graphique de ces grandeurs est donnée sur la fig. 2. Ici la sensibilité des plaques est évidemment déjà exclue et l'on obtient $\Delta \log I_\lambda$—la différence des logarithmes des intensités de la lumière. Il est évident que l'intensité de la lumière dans la région ultra-violette du spectre est relativement plus grande dans la lumière du ciel nocturne que dans la lumière crépusculaire et celle du jour. Si l'on admet qu'en $\lambda = 4358$ Å les intensités du rayonnement soient égales, on aura en point 10 ($\lambda = 3270$ Å) deux fois plus de lumière du ciel nocturne que du ciel crépusculaire et du jour. La divergence a un caractère systématique et dépasse les erreurs d'obser-

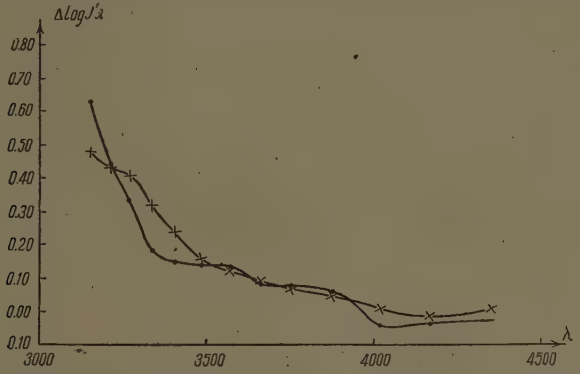

Fig. 2. ● — nuit minus jour, × — nuit minus demi-jour.

vations. Nous considérons comme un fait établi l'excès des rayons ultra-violets dans la lumière du ciel nocturne. Quant à l'évolution quantitative de cet excès, elle ne porte pour l'instant qu'un caractère préliminaire.

Sans doute, un certain enrichissement du spectre ultra-violet de nuit en énergie a lieu grâce au rayonnement propre du ciel. Mais par contre, on sait que les raies et les lignes du rayonnement du ciel sont très peu intenses dans la partie ultra-violette du spectre et il est possible, que le phénomène observé est causé par les conditions particulièrement heureuses de dispersion de la radiation solaire à courtes ondes par les couches supérieures de l'atmosphère, par suite d'une forte refringence selective, due à la dispersion anomale près de la raie d'absorption de l'ozone et de l'oxygène. La présence sur le fond continu des raies de Frauenhofer semble confirmer cette hypothèse. Dans ce cas on peut s'attendre à une polarisation apparente de la lumière du ciel nocturne dans la région de 3000—4000 Å.

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CHEMISTRY

HYDROXYLAMINE-THIOUREA PLATINUM COMPOUNDS

By V. I. GOREMYKIN

(Communicated by N. S. Kurnakov, Member of the Academy, 27. II. 1939)

In this publication we are studying the action of thiourea on non-electrolytic complexes of the types $|Pt2AX_2|\rightarrow$ and $|PtA_1A_2X_2|$ which contain hydroxylamine, in order to check the applicability of N. S. Kurnakov's rule to compounds of trans-configuration, which was discovered by other means. The following complexes were examined: $|Pt2HxCl_2|$*; $|PtHxNH_3Cl_2|$; $|PtHxPyCl_2|$** and $|PtNH_3PyCl_2|$.

These compounds were obtained according to the following equations:

$$K_2|PtCl_4| \xrightarrow{+4\,Hx + NaOH} |Pt4Hx|(OH)_2 + HCl \rightarrow |Pt2HxCl_2|$$

$$cis\,|Pt2NH_3Cl_2| \xrightarrow{+2\,Hx + NaOH} |Pt2Hx2NH_3|Cl_2 + HCl \rightarrow |PtHxNH_3Cl_2|$$

$$cis\,|Pt2PyCl_2| \xrightarrow{+2\,Hx + NaOH} |Pt2Hx2Py|Cl_2 + HCl \rightarrow |PtHxPyCl_2|$$

$$cis\,|Pt2NH_3Cl_2| \xrightarrow{2Py} |Pt2NH_32Py|Cl_2 + HCl \rightarrow |PtNH_3PyCl_2|$$

From the method of their production it may be assumed that these complex compounds are of trans-configuration, since, according to Jerguenson's principle, the decomposition of cis-tetramines by hydrochloric acid results in the trans-diamine of the same name or in a mixed trans-diamine. Up till now we did not know of any complex compounds which contained hydroxylamine, thiourea and platinum at the same time. N. S. Kurnakov (1) showed that when thiourea reacts with a diamine of the general formula $|Pt2AX_2|\rightarrow$, it gives various reaction products depending on the structure of the compound. Thus, for instance, in complexes of cis-configuration thiourea displaces both acid radicles and neutral substitutors according to the equation:

$$\left|\begin{matrix} A \\ A \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} Cl \\ Cl \end{matrix}\right| + 4Th^{***} \longrightarrow |Pt4Th|Cl_2 + 2A;$$

while with complexes of the same type, but of trans-structure, it gives a mixed tetramine:

$$\left|\begin{matrix} Cl \\ A \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} A \\ Cl \end{matrix}\right| + 2Th \longrightarrow \left|\begin{matrix} Th \\ A \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} A \\ Th \end{matrix}\right| Cl_2.$$

* Hx stands for hydroxylamine NH_2OH.
** Py stands for pyridine C_5H_5N.
*** Th stands for thiourea $Cs(NH_2)_2$.

This selective ability of thiourea may be explained, according to Černjaiev's theory (²), through the strong «trans-influence» of thiourea. Experiments which were performed by us showed that complex compounds which contain hydroxylamine behave analogously to pyridine compounds in reaction with thiourea. We did not observe any anomalous phenomena. When the thiourea was in very small excess, and the conditions under which it was instilled in the complex were mild, the resulting products did not contain any admixtures and are always liberated entirely pure. The following mixed hydroxylamine-thiourea platinum compounds were produced: $|Pt\,2Hx\,2Th|Cl_2$; $|PtHxNH_3\,2Th|Cl_2$; $|PtHxPy\,2Th|Cl_2$; $|PtNH_3Py\,2Th|Cl_2$; their properties and decomposition reactions with HCl have been studied. We made determinations of their molecular electroconductivity and attempted to produce their derivatives: oxalates, chlorplatinates, but were unsuccessful.

Trans-dihydroxylamine-dithiourea-platinum chloride $|Pt\,2Hx\,2Th|Cl_2$. One gram of Alexander's non-electrolyte $|Pt\,2HxCl_2|$, well ground, is added in small portions to 0.55 g of thiourea, dissolved in 5 ml water in a porcelain evaporating dish at usual temperature, grinding constantly with a glass stirring rod or better with a pestle. The thiourea should be taken in a quantity about 15—20% more than the theoretical. The orange non-electrolyte crystals gradually dissolve in the thiourea, giving the solution a yellow-brown colour. In 20—40 min. the colour of the solution disappears. The reaction ends. At this time the colourless solution begins to precipitate a white crystalline substance, which under the microscope proves to be in the form of short thick rods or prismatic concretions. In order to precipitate this substance completely, the solution is treated with a mixture of alcohol and ether and is left standing a while. Then the precipitate is filtered through Gersch's funnel, washed a few times with concentrated alcohol, dried in the exsiccator over sulphuric acid or phosphorous pentoxide for 12—24 hours, and analyzed. The results of the analysis were as follows:

0.1089 g	substance	gave	0.044 g Pt
0.1090 »	»	»	0.0437 g Pt
0.1352 »	»	»	0.0788 g AgCl
0.1169 »	»	»	0.0694 g AgCl

Calculated for $\|Pt2Hx2Th\|Cl_2$	Found
% Pt— 40.31	40.40; 40.09
% Cl— 14.64	14.40; 14.68

The substance dissolves well in water and dilute alcohol, dissolves poorly in concentrated alcohol and concentrated hydrochloric acid. The molecular electroconductivity, determined in aqueous solution at 25°, is in full accordance with Werner and Miolati's data for electrolytes of this type. The tetramine decomposes into a complex ion with two charges $|Pt\,2Hx\,2Th|^{++}$ and two simple chlorine ions $2Cl'$:

v	1000	2000	4000
μ_v	249.86	268.00	285.40

The tetramine precipitates from its solution upon being treated with hydrochloric acid (1 : 1) and heated over a water bath for 1.5—2 hours. The precipitate turns slightly yellow, and the solution turns a brownish-red colour. After being filtered, washed with concentrated alcohol, and dried in the exsiccator over sulphuric acid, the precipitate was analyzed. The data of analysis coincide with the initial substance, but the per cent of platinum

is a little higher (0.5—1.2%). Apparently, in this case the tetramine becomes tarred and does not decompose into two diamines, as it should according to Jerguenson's rule. Repeated experiments which we performed with concentrated HCl and more prolonged heating gave the same results.

Trans-hydroxylamine-ammonia-dithiourea-platum chloride $|PtHxNH_3 2Th|Cl_2$. The reaction of instilling thiourea in the non-electrolyte $|PtHxNH_3Cl_2|$ is brought about under the same conditions as in the former case. In the beginning the solution has a yellowish-green colour, which loses its intensiveness in time and disappears entirely just before the white crystalline precipitate appears. The reaction goes on only a few minutes. The substance precipitates in the form of thin short rods. After drying it was analyzed and gave the following results:

0.0867 g substance gave 0.0365 g Pt
0.1195 » » » 0.0501 g Pt
0.0867 » » » 0.0531 g AgCl
0.1195 » » » 0.0744 g AgCl

Calculated for $\|PtHxNH_3 2Th\|Cl_2$	Found
% Pt—41.68	41.84; 42.10
% Cl—15.14	15.15; 15.38

The tetramine $|PtHxNH_3 2Th|Cl_2$ resembles the former substance in many properties. Hydrochloric acid decomposes the tetramine even less and therefore has hardly any effect on the percentage content of platinum in the precipitate. The data from measuring the molecular electroconductivity are in accordance with the formula given this complex, which splits up into three ions in aqueous solution at 25°:

v	1000	2000	4000
μ_v	244.10	247.98	258.70

Trans-hydroxylamine-pyridine-dithiourea-platinum chloride $|PtHxPy 2Th|Cl_2$. Differs from the former experiments in that the non-electrolyte $|PtHxPyCl_2|$ was introduced into a thiourea solution, acidified with a few drops of dilute acetic acid, since the initial substance, containing pyridine, loses it easily in even slightly basic solution. The stability of the bond between pyridine and platinum was mentioned in one of our papers (2). The end of the reaction can be determined by the disappearance ot the pale-green colour of the solution. The precipitate does not appear at once. The colourless tiny thin rods were analyzed after being washed and dried for twenty four hours in the exsiccator over phosphorus pentoxide. The data of analysis were as follows:

0.1060 g substance gave 0.0389 g Pt
0.1177 » » » 0.0434 g Pt
0.1084 » » » 0.0588 g AgCl
0.1177 » » » 0.0631 g AgCl

Calculated for $\|PtHxPy2Th\|Cl_2$	Found
% Pt—36.81	36.87; 36.70
% Cl—13.37	13.26, 13.42

The molecular electroconductivity taken in aqueous solution at 25° does not exceed the limits set by Werner and Miolati for electrolytes of this type:

v	1000	2000	4000
μ_v	202.90	209.70	214.80

Trans-ammonia-pyridine-dithiourea-platinum chloride $|PtNH_3Py\,2Th|Cl_2$. This tetramine is produced analogously to the former, with the only difference that the thiourea is taken in an accurately calculated quantity. The instillation reaction goes on slowly and is completed in 1—2 hours. Sometimes, for a reason which has not yet been established, we are unsuccessful in producing this substance. The tiny colourless broken rods which precipitate have the same properties as the former tetramines. Analyses of the substance dried over sulphuric acid gave satisfactory results:

0.0730 g substance gave 0.0278 g Pt
0.1286 » » » 0.0726 g AgCl

Calculated for $|PtNH_3Py2Th|Cl_2$	Found
% Pt—37.95	38.08
% Cl—13.79	13.97

Determination of the molecular electroconductivity at 25° gave the following results:

v	1000	2000	4000
μ_v	—	237.40	240.80

These data are well within the limits given by Werner and Miolati for electrolytes, which dissociate in aqueous solution into three ions: one complex cation with two charges and two simple chlorine ions. The study is being continued.

Conclusions

The instillation of thiourea in non-electrolytes containing hydroxylamine goes on normally. N. S. Kurnakov's thiourea reaction is applicable in establishing the configuration of hydroxylamine diamines.

The following compounds have been produced for the first time: $|Pt\,2Hx\,2Th|Cl_2$; $|PtHxNH_3\,2Th|Cl_2$; $|PtHxPy\,2Th|Cl_2$; $|PtNH_3Py\,2Th|Cl_2$.

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CHEMISTRY

OXALATES OF AMMONIUM-PYRIDINE PLATINUM COMPOUNDS

By V. I. GOREMYKIN and K. A. GLADYSHEVSKAJA

(Communicated by N. S. Kurnakov, Member of the Academy, 27.II.1939)

L. A. Chugaev was the first to draw attention to the necessity of synthesizing a great variety of classes of complex compounds of the platinic metals. This desire could be fulfilled if it were possible, for instance, to substitute chlorine with amines within the inner sphere of the complex $K_2|PtCl_4| \rightarrow$ in various ratios and differing in composition and structure.

Besides, it would evidently be necessary to vary the composition of the complex compound in both the inner and outer spheres by means of acid radicles varying in nature and character. The results of such a study of compounds of higher order would expand our knowledge of the influence of neutral and acid substitutors over the behaviour and properties of the complex molecule in relation to its composition and co-ordinational structure.

In this respect the studies of Chugaev and Kiltinovitch[1] «On the ammonium compounds of platonitrite» are quite instructive; as we know, they solved a number of disputable problems, established those properties of nitrites which are typical of the nitrogroup and served as a basis for a more extensive study, which led Černjaiev[2] to the discovery of a new principle which he called «trans-influence». A great many works have appeared at various times, in which the influence of acid radicles on the physico-chemical properties of complex platinum compounds is treated, and it may be referred here to only a few of them: Clévé [3] (oxalates), Greenberg [4] (oxalates and rhodonates), Černjaiev [5] (nitrochlorides), Ryabchikov [6] (hyposulphites).

Greenberg repeated Clévé's experiments, proposed a new method of producing oxalates and gave a new interpretion for the structure of oxalates, which belong to the type $|Pt2AX_2|$. In our work we applied Greenberg's method in producing oxalates of the diamine series $|Pt\,2AX_2|$, slightly changing the reaction conditions and the concentration of the initial substances. Aqueous nitrate solutions of the composition $|Pt\,2A\,2NO_3| \rightarrow$ react with oxalic acid as follows, depending on the structure of the complex:

$$\left|\begin{matrix} A \\ A \end{matrix}\!\!>\!\!Pt\!<\!\!\begin{matrix} NO_3 \\ NO_3 \end{matrix}\right| + H_2C_2O_4 \longrightarrow \left|\begin{matrix} A \\ A \end{matrix}\!\!>\!\!Pt\!<\!\!\begin{matrix} OOC \\ | \\ OOC \end{matrix}\right| + 2HNO_3 \qquad (I)$$

forming a stable cycle which, however, decomposes in acids (HCl, H_2SO_4, etc.). In the diamine trans-configuration oxalic acid displaces both nitrate radicles, producing the bioxalate:

$$\left|\begin{matrix} NO_3 \\ A \end{matrix}\!\!>\!\!Pt\!<\!\!\begin{matrix} A \\ NO_3 \end{matrix}\right| + 2H_2C_2O_4 \longrightarrow \left|\begin{matrix} HC_2O_4 \\ A \end{matrix}\!\!>\!\!Pt\!<\!\!\begin{matrix} A \\ HC_2O_4 \end{matrix}\right| + 2HNO_3. \qquad (II)$$

Therefore, the structure of the complex influences the course of the reactions between $|Pt\,2A(NO_3)_2|$ and $H_2C_2O_4$; in the latter case (equation II) oxalic acid acts as a secondary dissociation product HC_2O_4', and, as a rule, the final reaction products contain crystallization water. Only in rare cases is it possible to obtain a direct interchange reaction between tetramines $|Pt\,4A|X_2$ and $H_2C_2O_4$.

$$|Pt4A|X_2 + H_2C_2O_4 \longrightarrow |Pt4A|C_2O_4 + 2HX. \qquad (III)$$

The best way to obtain this reaction is by using the alkali salts instead of free oxalic acid. We were successful in obtaining reactions in accordance with equations I and II and in producing pure cis $|Pt\,2PyC_2O_4|$* and trans $|PtNH_3Py\,2HC_2O_4|\cdot 4H_2O$. We obtained such small quantities of trans $|Pt\,2Py2HC_2O_4|$ aq. that we were unable to study it and produce its derivatives. They are colourless crystalline substances, slightly soluble in water and recrystallizing comparatively easily from water. Purified oxalates are initial material for producing more complicated complex compounds of tetramine oxalates.

In this work we set before us the task of studying how physical and chemical properties of ammonia-pyridine complex compounds are affected by a change in the ratio of ammonia to pyridine in the inner sphere of the complex cation, leaving the same anion, say, oxalic acid, which is mostly capable of giving a stable cycle $\begin{matrix}COO\\|\\COO\end{matrix}$ or, if the complex anion $|PtCl_4|''$ or $|PdCl_4|''$ is available, which differ only in the central atom. To this purpose we had to synthetize the following complexes which were unknown up till now: $|Pt\,4Py|C_2O_4\cdot H_2O$; $|PtNH_3\,3Py|C_2O_4$; cis $|Pt\,2NH_3\,2Py|C_2O_4\cdot 2H_2O$; trans $|Pt\,2NH_3\,2Py|C_2O_4\cdot 2H_2O$; $|Pt\,3NH_3Py|C_2O_4$.

Tetramine oxalates are colourless crystalline substances, dissolving in water and diluted alcohol, with great but no equal ease, and less soluble in strong alcohol. It is very difficult to produce them in their pure form. Neither alcohol, nor a mixture of alcohol and ether precipitates them from their aqueous solutions. If evaporated in a vacuum over sulphuric acid, their solutions almost always give sticky masses which can be transformed into the crystal state only after prolonged grinding and manifold treatment with strong alcohol. An analysis showed full accordance with the formula ascribed them. The structure is established from the method of their production:

$$\text{cis}\,|Pt2PyC_2O_4| + 2Py \longrightarrow |Pt4Py|C_2O_4$$
$$\text{trans}\,|PtNH_3Py2HC_2O_4| + 2Py \longrightarrow |PtNH_3Py|C_2O_4 + H_2C_2O_4$$
$$\text{cis}\,|Pt2NH_3C_2O_4| + 2Py \longrightarrow |Pt2NH_32Py|C_2O_4\ \text{cis}$$
$$\text{trans}\,|Pt2NH_32HC_2O_4| + 2Py \longrightarrow |Pt2NH_32Py|C_2O_4\ \text{trans} + H_2C_2O_4$$
$$\text{trans}\,|PtNH_3PyCl_2| + 2NH_3 \longrightarrow |Pt3NH_3Py|Cl_2 + K_2|PtCl_4| \rightarrow$$
$$\rightarrow |Pt3NH_3Py||PtCl_4| + 2HCl$$
$$|Pt3NH_3Py||PtCl_4| + |Pt4NH_3|C_2O_4 \rightarrow |Pt3NH_3Py|C_2O_4 + |Pt4NH_3||PtCl_4|$$

The last tetramine is obtained not altogether pure. The changes in molecular electroconductivity at 25° show high values for the oxalates. Oxalate solutions, acidified with acetic acid reach with $K_2|PtCl_4|$ and $K_2|PdCl_4|$ to form chiefly slightly soluble chlorplatinates and chlorpalladites. It is interesting to note the regularity observed in the colour of the chlorplati-

* Py stands for pyridine—C_5H_5N.

nate crystals from the cation $|Pt4Py|^{++}\rightarrow$ to the cation $|Pt4NH_3|^{++}\rightarrow$* depending on the quantitative substitution of pyridine by ammonia in the cation $|Pt4Py|^{++}$:

$|Pt4Py||PtCl_4|$ $|PtNH_33Py||PtCl_4|$ cis $|Pt2NH_32Py||PtCl_4|$
trans $|Pt2NH_32Py||PtCl_4|$ $|Pt3NH_3Py||PtCl_4|$ $|Pt4NH_3||PtCl_4|$

Chlorpalladites repeat this regularity:

$|Pt4Py||PdCl_4|$ $|PtNH_33Py||PdCl_4|$ cis $|Pt2NH_32Py||PdCl_4|$
trans $|Pt2NH_32Py||PdCl_4|$ $|Pt3NH_3Py||PdCl_4|$ $|Pt4NH_3||PdCl_4|$

Conclusions

1. Pyridine and ammonia can substitute the oxalate and bioxalate radicles in the complexes of the $|PtA_1A_2X_2|$ | Pt2AX$_2$ | diamine series, forming tetramine oxalates.

2. The following oxalates of the tetramine and diamine series have been produced:

$|Pt4Py|C_2O_4\cdot H_2O$, $|PtNH_33Py|C_2O_4$, cis $|Pt2NH_32Py|C_2O_4\cdot 2H_2O$
trans $|Pt2NH_32Py|C_2O_4\cdot 2H_2O$, $|Pt3NH_3Py|C_2O_4$,
cis $|Pt2PyC_2O_4|$ and $|PtNH_3Py2HC_2O_4|\cdot 4H_2O$.

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* The chlorplatinates and chlorpalladites are: $|PtNH_33Py||PtCl_4|$; $|Pt3NH_3Py||PtCl_4|$; $|PtNH_33Py||PdCl_4|$; $|Pt3NH_3Py||PdCl_4|$.

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CHEMISTRY

AN X-RAY STUDY OF THE STRUCTURE OF TERNARY SOLID SOLUTIONS OF ALUMINIUM WITH MAGNESIUM AND SILICON AND THEIR AGEING

By V. G. KUZNETZOV and E. S. MAKAROV

(Communicated by N. S. Kurnakov, Member of the Academy, 28. II. 1939)

The aluminium corner of the diagram of state for the system aluminium-magnesium-silicon was first studied by Hanson and Gayler (1). These investigators showed that a quasi-binary section Al-Mg_2Si is present in the system in the region of ternary solid solutions of magnesium and silicon in aluminium, which decreases as the temperature is lowered; and they also showed that the aluminium solid solution is able to harden (to age), while it is maintained at temperatures 100—200° C.

To the present day this striking property of «ageing», discovered by Wilm (2) while working with duraluminum, is widely used in industry for the preparation of various brands of aluminium alloys, in which the basic additions are silicon and magnesium. To this type belong such alloys (known by the following trade names) as: aldrey, which contains 0.55% of silicon and 0.43% of magnesium; almalak, which contains 0.6% of silicon and 0.7% of magnesium; 51S, pental, aldur, and others. The latter contains 0.6—2% of magnesium and 0.5—1% of silicon with an addition of 0.4—1.4% of manganese. Alloys of aluminium with silicon (up to 20% of silicon) and small additions of other metals, furthermore, possess exceptional casting properties and are known under the name of silumins.

The next investigation of the solubility of magnesium and silicon in aluminium in the solid state, carried out by Dix, Keller and Graham (3) for a quasi-binary section and by Bochvar, Gorev and Korolkov (4) for the entire aluminium corner, supplemented the data of Hanson and Gayler with more accurate values for the solubility at various temperatures.

Gayler and Preston (7), Kokubo (6), Urazov and Shushpanova (8), and Bochvar and his co-workers (4), investigating the processes of the ageing of aluminium alloys containing various additions of magnesium and silicon, in general upheld Hanson and Gayler's conclusions that these alloys are characterized by their ability to age and that the stabilizing phase in these alloys is magnesium silicide (Mg_2Si).

However, the question whether magnesium silicide exists in the solid solution as an independent molecular complex, or is distributed in the

atomic state within the crystalline lattice of the solid solution, remains a disputed point up to the present time. The answer to this question is very important for an understanding of the mechanism of the ageing of solid solutions of magnesium and silicon in aluminium, and also for an understanding of the mechanism of the ageing of duraluminum—the most widely used light alloy at the present time—which contains Mg and Si as additions.

Cases of formation of molecular complexes in other ternary systems of an analogous type are not known. Thus, Wassermann ([10]), after an X-ray study of the alloys of aluminium with $MgZn_2$, came to the conclusion that the solid solutions of Al-$MgZn_2$ are atomic in structure. However, in binary systems, for example copper-gold and others, it was shown by N. V. Ageyev and D. Shoichet ([5]) and by N. V. Ageyev ([9]), on the basis of a study of the order, that the molecular complexes AuCu and Au_2Cu_3 are formed within the solid solution. Henstenberg and Wassermann ([11]) point to the segregation of the copper atoms in alloys with aluminium during ageing.

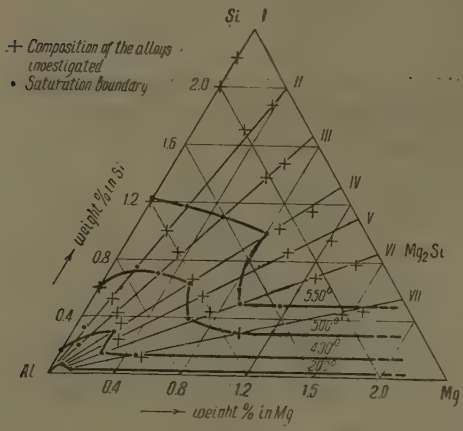

Fig. 1.

Gayler and Preston ([7]) and Kokubo ([6]) assume the formation of magnesium silicide in the aluminium solid solution in the initial stages of ageing, while more definite proof is given in the work of Urazov and Shushpanova ([8]).

According to the data of Urazov and Shushpanova, the Brinell hardness and the temporary resistance to rupture of alloys lying on the quasi-binary section turn out to be the least in comparison with alloys containing either excess of magnesium or excess of silicon, even though the total amount of magnesium and silicon is the same. This led to the conclusion that the molecule Mg_2Si may exist in the solid aluminium solution.

Since a systematic X-ray study of the ternary solid solution of magnesium and silicon in aluminium had not been undertaken up to the present time, except for individual alloys of the pseudo-binary section ([7]), it was decided to examine the entire region of the ternary solid solution roentgenographically with the aim of checking the hypothesis of the existence of molecular complexes in the solid solution. It was also decided to determine the change in the parameters in the solid solution in different directions, the boundary of the solubility of magnesium and silicon at various temperatures, and the effect of artificial and natural ageing on the change in the parameter of the lattice and on the character of the lines in the roentgenograms when the composition of the solid solution is varied within a wide range.

The investigation was carried out along six radial sections of the aluminium corner of the system Al-Mg-Si up to a total magnesium and silicon content of 2.2%, and was carried out with the binary alloys of aluminium with silicon up to a 2.2% silicon content. The starting material was aluminium DAZ bearing the trade mark A_0 and containing: silicon 0.25—0.30% and iron 0.08—0.14%. The alloys, which were very kindly furnished by G. G. Urazov, were prepared elsewhere and were made homogeneous by heating at a temperature of 550° C for a period of 15 days.

The values for the parameters of the alloys, tempered at 550, 500, 400 and 200° C, were determined by the X-ray method of Debye, Preston and Saks. On the basis of these data, solubility isotherms were constructed for the aluminium corner of the system Al-Mg-Si (Fig. 1), whereby methods of determining the boundary of the phases in the ternary systems along the sections were made use of. Our data for the solubility at 400° and higher may be regarded as corroborating, in general, the diagram presented by Urazov and Shushpanova ([8]), which they constructed on the basis of the data of Bochvar and his co-workers ([4]) and other authors. However, at 200° C the region of the solid solution is considerably smaller according to our data.

Furthermore, employing the data obtained from a study of the binary systems aluminium-silicon and aluminium-magnesium ([13], [14]), an equation was developed for the change on the lattice parameter of the aluminium ternary solid solution in the case of an atomic structure: $a = 4.0412 + 0.0040$ (atomic % Mg) $- 0.0027$ (atomic % Si), where 4.0412 Å is the parameter of the original aluminium.

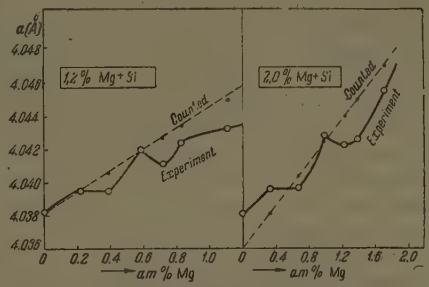

Fig. 2. Experiment and counted curves of changes in the parameters according to composition for sections with constant content of total magnesium and silicon. Alloys tempered at 550°.

In Figs. 2 and 3 there are presented curves calculated with this equation and also experimental curves of the change in the parameters of the solid solution for two of the four sections studied, with the concentration given in atomic percents and a constant total magnesium and silicon content of 1.2 and 2%. Curves are also given for two radial sections of a sample which had been tempered at 550° C. An analogous but more diffuse picture is also obtained for the lower tempering temperatures.

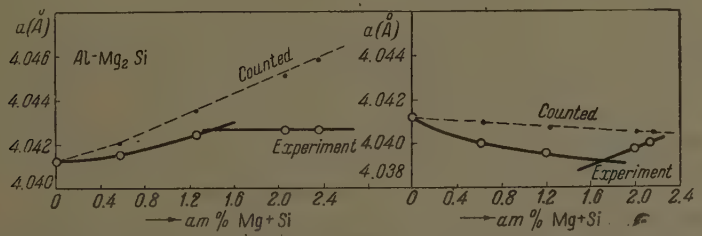

Fig. 3. Experiment and counted curves of changes in parameters according to composition for radial sections. Alloys tempered at 550°.

Upon an examination of the results obtained, the first thing that comes to our attention is the completely different character of the experimental and calculated curves. The calculated curve, as follows from the equation, is a straight line, while the experimental curve, for all sections with a constant aluminium content, does not give a linear relation for the change in the parameters of the lattice of the solid solution with the composition. For the radial sections the experimental curve also considerably deviates from the calculated, except for one section which passes along the line of simultaneous saturation with silicon and magnesium silicide.

It of is interest to note that the shape of the curve of the change in the parameter with the composition is analogous to the solubility isotherms. The parameter increases with an increase in the magnesium content, possessing a slight inflexion in the region of the second and third radial sections (Fig. 1), and finally rises sharply to the line representing simultaneous saturation with silicon and magnesium silicide, which corresponds exactly to the fourth radial section. After this the parameter decreases, passes through a minimum corresponding approximately to a composition somewhat shifted to the side of silicon from the pseudo-binary section Al-Mg_2Si, and then again begins to rise sharply in passing over into the region rich in magnesium. Such a correspondence, evidently, is not accidental if one remembers that the value of the parameters of the solid solution depends above all upon the concentration of the dissolved components. Just as the shape of the curve representing the solubility is due to the presence of the chemical compound Mg_2Si in the system Al-Mg-Si, so the curve representing the change in the parameters with the composition reflects the structural peculiarities connected with the formation of molecular complexes of magnesium silicide in the homogeneous solid solution.

Therefore, taking note of the fact of the disagreement between the calculated and experimental curves of the change in the parameters with the composition, and keeping in mind the peculiarities in the behaviour of the hardness and the resistance to rupture in the region of the quasi-binary section ([8]), we draw the conclusion that magnesium silicide is distributed in a molecular state in the aluminium solid solution in the system Al-Mg-Si.

However, all attempts to locate the lattice of magnesium silicide on the roentgenograms of the alloys, aged for a period of 150 hours at 200° C, gave no positive results, which fact may be put down to the insignificant amount of magnesium silicide present in the alloy.

The question concerning what fraction of the atoms of magnesium and silicon are bound in such complexes and how the latter are constructed within the solid solution, and also the question concerning the mechanism of disintegration upon ageing, require further study.

The results of the investigation of the natural and artificial ageing of alloys of Al-Mg-Si at 150, 175 and 200°C lead to the conclusion that the ageing of tempered alloys at room temperature does not cause a change in the parameters within the limits of experimental errors. With artificial ageing the lattice constants change in such a manner as to approach the parameter of pure aluminium, and this points to the disintegration of the solid solution. Deformation after tempering very markedly accelerates the process of the disintegration of the binary alloys and the alloys of the quasi-binary section Al-Mg_2Si, which confirms the investigations carried out by Konobeyevsky and Zacharova ([12]).

The exographs of the thin-sections for artificial and naturally aged alloys, obtained with a Saks and Preston camera, display diffuse interference lines which disintegrate partly into a whole series of lines, each one corresponding to a definite composition of the given grain. This points to the heterogeneity of the composition of alloys due to the irregularity and also to the tenseness of the state and the marked distortion of the lattice. All this points to the difficulty of obtaining alloys in the equilibrium condition.

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CHEMISTRY

CATALYTIC CYCLIZATION OF 2.6-DIMETHYLOCTANE IN THE PRESENCE OF PLATINIZED CHARCOAL

By B. A. KAZANSKY, A. F. PLATE and E. E. GOLDMAN

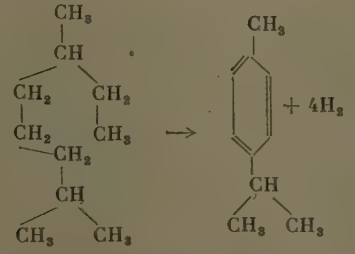
(Communicated by N. D. Zelinsky, Member of the Academy, 11. II. 1939)

It is well known that derivatives of 2.6-dimethyloctane (particularly those containing oxygen) have the property of undergoing cyclization with the formation of *p*-menthane derivatives. Thus, under the influence of acids, citrinellal is easily converted into isopulegol (1), geraniol—into terpinhydrate and α-terpineol (2), nerol—into terpinhydrate, etc.

It seemed interesting to study the behaviour of 2.6-dimethyloctane itself when heated in contact with platinized activated charcoal, i. e. under the conditions when, as we had shown previously (3), paraffinic hydrocarbons undergo cyclization and a partial transformation into benzene homologues.

2.6-dimethyloctane was prepared by two methods: by the hydrogenation of allo-ocimene and by the decomposition of the hydrazone of citral according to Kishner (4). In both cases we obtained preparations of 2.6-dimethyloctane having nearly the same properties.

When 2.6-dimethyloctane was passed over platinized charcoal, there was a marked increase in the refractive index of the condensate, thus proving that the formation of an aromatic hydrocarbon had taken place. This hydrocarbon was absorbed with sulphuric acid, the sulfonic acid was converted into its barium salt, and the latter proved by its properties to be identical with the barium salt of the *p*-cymene-α-sulfonic acid (5). We could presume, therefore, that the reaction had taken place, as it was to be expected, according to the following scheme:



Preparation of 2.6-dimethyloctane. Allo-ocimene having a b. p. 81—83°/13 mm and $n_D^{20} = 1.5420$ was passed at a temperature of 170° over nickel on asbestos in a current of hydrogen. A saturated product

was obtained which failed to discolour an alkali permanganate solution and proved to have the following properties: b. p. 159—160°/749.5 mm; n_D^{25} = =1.4139; d_4^{25} = 0.7280; MR = 48.73; MR, calculated for $C_{10}H_{22}$, 48.38.

A second sample of 2.6-dimethyloctane was obtained from citral. The hydrazone of the latter was obtained in an alcohol solution. The alcohol was distilled and the hydrazone dried over solid potassium hydroxide. Then, without distilling it in vacuo (to avoid the formation of a pyrazoline base), the hydrazone was decomposed by heating it with potassium hydroxide and platinized charcoal. The decomposition proceeded vigorously, the temperature of the oil bath being 140—168°. The diolefinic hydrocarbon obtained was washed with hydrochloric acid, dried over calcium chloride and hydrogenated in the presence of nickel on asbestos. This sample of 2.6-dimethyloctane had the following properties: b. p. 155—157°/749 mm; n_D^{17} = 1.4170; d_4^{17} = 0.7329; MR = 48.74; MR, calculated for $C_{10}H_{22}$, 48.38.

Catalytic Cyclization of 2.6-dimethyloctane. The reaction was carried out in the usual apparatus—a glass tube containing platinized charcoal that was placed in an electric oven, heated to 305—310°. The hydrocarbon was added from a calibrated dropping funnel and was passed through the tube in a feeble current of nitrogen which had been preliminarily passed through another tube with reduced copper at 430—450°.

The condensate was collected in an ice-cooled receiver. After passing the hydrocarbon twice over the catalyst, the refractive index of the condensate was n_D^{27} = 1.4214. Sulphuric acid containing 3% of SO_3 absorbed an aromatic hydrocarbon which amounted to 10% of the condensate. The sulphuric acid solution was neutralized with barium carbonate and the precipitate boiled repeatedly with hot water. The mixture was filtered hot and the filtrate was evaporated up to the beginning of crystallization of the barium salt of the sulfonic acid. The crystals were separated, recrystallized from hot water, dried on filter paper, and the amount of crystallization water was determined.

Sample of the salt 0.2050 g; found H_2O—0.0152 g, i. e. 7.41%. Calculated for $(C_{10}H_{13}SO_3)_2$ $Ba.3H_2O$—H_2O 8.75%.

A sample of the salt was dried at 140° and the barium content in the anhydrous salt was determined. Sample 0.1876 g; found Ba—0.0463 g, i. e. 24.58%. Calculated for $(C_{10}H_{13}SO_3)_2$ Ba—Ba 24.33%.

Conclusions. The hydrogenation of 2.6-dimethyloctane over platinized charcoal at a temperature of 305—310° leads to its partial conversion into *p*-cymene.

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CHEMISTRY

ACTIVATION ENERGY AND HEAT OF MELTING OF FATTY ACIDS AND TRIGLYCERIDES CALCULATED FROM TEMPERATURE RELATIONS OF VISCOSITY

By M. P. VOLAROVICH and G. B. RAVICH

(Communicated by N. S. Kurnakov, Member of the Academy, 16. II. 1939)

A number of works published within recent years have attempted to place a theoretical foundation under the exponential formula for the relationship between temperature and viscosity of a liquid, expressed by

$$\eta = Ae^{\frac{B}{RT}} \qquad (1)$$

(where η is viscosity, T is absolute temperature and A, B and R are constants) or in somewhat more complex form, where A and B are functions from temperature and volume. Similar equations have been more than once used since 1913 as empirical formulae (1). Attempts at establishing the equation (1) theoretically were made by Raman (2), Andrade (3), Sheppard(4), etc.

Ewell(5) developed a formula, similar to the equation (1), proceeding from Eyring's (6) theory of chemical reaction velocities based on a conception of potential barrier. From the latter theory follows that the so-called activation energy of molecules B is a certain definite part of the heat of evaporation. On the other hand, Ward(7) developed the equation (1) on the basis of Bernal's (8) theory of liquids, the energy B being for certain kinds of liquids close to the heat of melting L, according to the conceptions of the latter authors. In general the ratio B/L must be constant for the liquids of the same type. These conclusions of Bernal and Ward are in better agreement, than those of Ewell and Eyring, with the results of theoretical considerations of Frenkel (9), who on developing the equation (1) assumes B to be near to the heat of melting. It ought to be mentioned that Gusman has already discovered empirically the proximity of B and L.

In our laboratory of the Petrographic Section of the Institute for Geological Sciences of the Academy of Sciences, A. A. Leontieva applied the equation (1) to a number of vitreous systems. One of the present authors applied the same equation to some systems of fieldspars and pyroxenes at the temperatures up to 1600°. Preston and Seddon (10), as well as Stanworth (11) suggested the same formula for the study of glass structure.

In connexion with their previous works (12) on the viscosity and other physico-chemical properties of higher fatty acids and triglycerides of varying degree of saturation, the authors deemed it wise to apply the equation (1)

to those compounds and calculate their heats of melting at least approximately. The latter point is of considerable practical interest in view of the alteration of thermal constants, say the heat of melting, in the process of hydrogenation of vegetable oils. It ought to be mentioned that the authors had already used the formula (1) in their previous studies ([13]) in the form proposed by Fulcher and Tamman.

The results obtained by the authors for a series of fatty acids with eighteen carbon atoms are expressed graphically in Fig. 1, where the values $\frac{1}{T} \cdot 10^5$ (abscissae) are plotted against the decimal logarithms of viscosity, expressed in centipoises (ordinates). The numeration of lines in Fig. 1 for fatty acids and triglycerides is the same as in the table.

In the figure we see the lines for fatty acids to run nearly straight at temperatures ranging from 20 to 110°C. It may therefore be concluded that fatty acids in liquid state show insignificant changes in the co-ordination number of molecules, when temperature is rising within the range mentioned. More considerable alterations can, perhaps, take place at lower temperatures.

From the straight lines, obtained in Fig. 1, the values of the coefficient B for fatty acids have been calculated. These values are given in the first column of the table, B being expressed in Cal./mol.; R in the formula (1) is, in this case, the universal gas constant which was assumed to be 1.987 Cal./mol. grad.

Compound	B	B_1	L	B/L	J
Linolenic acid	4.78	—	—	—	256.6
Linolic acid	5.15	—	—	—	200.1
Oleic acid	5.68	—	—	—	89.7
Stearic acid	5.87	—	13.5	0.435	0
Palmitic acid	5.05	—	10.0	0.505	0
Trioleate	7.75	4.6	—	—	79.1
Tristearate	9.4	4.6	—	—	—
Tripalmitate	8.0	5.05	—	—	0.9
Hydrogenated oil seed (sunflower oil)	6.85	4.8	30.0	0.228	—

Two intersecting lines resulted as a first approximation for triglycerides in Fig. 1. The value B is therefore not a constant for these compounds and the authors were compelled to calculate it for two intervals of temperature. The values of B given in the second column of the table correspond to the lower temperatures, while the same in the third column correspond to the higher ones. The intervals of temperature for B are respectively: from 20 to 60° for trioleate; from 70 to 100° for tristearate; from 70 to 100° for tripalmitate; from 50 to 90° for hydrogenated oil. Accordingly, for B_1 these intervals are from 60 to 90° for trioleate; from 100 to 120° for stearate; from 100 to 130° for tripalmitate; from 90 to 130° for hydrogenated oil.

The diagrams for triglycerides correspond, according to the views of Bernal and Ward, to the molecular liquids with directed forces (of a polarization character). An alteration in the co-ordination number of the molecules of these compounds, when in liquid state, takes place in the vicinity of the temperature of intersection of the lines. At lower temperatures the co-ordination number is less, owing to the presence of directed forces. With an increase in temperature the influence of directed forces goes down and the co-ordination number goes up. Consequently, the values of activation energy B_1 at higher temperatures are lower than B.

Thus, the fatty acids and triglycerides have to be considered, according to Bernal's classification of liquids, as molecular liquids with a hydroxyl or a hydrogen bond. The value B found by the authors as nearly 4—6 Cal./mol. (for triglycerides at higher temperatures) is in fact approaching that obtained by Ward (2—4 Cal./mol.) for a number of acids (for instance, acetic acid) and alcohols with a hydroxyl or hydrogen bond.

Since the formula of A. I. Bachinsky is not satisfied in case of a number of fatty acids *, the latter should be considered as associated, the degree of their association varying with temperature. However, the nearly rectilinear character of the diagrams in Fig. 1 shows that the degree of association is but slightly variable within the temperature range under consideration. The fatty acid molecules are, undoubtedly, far from being spherical and,

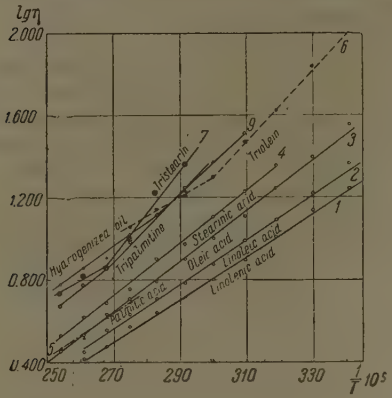

Fig. 1.

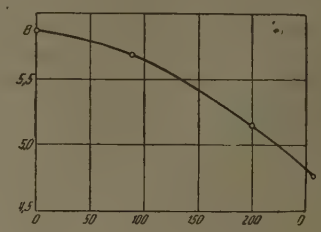

Fig. 2.

according to Bernal's classification, might be expected to possess some directed forces. However, it will follow from Fig. 1 that the magnitude of these forces, as well as the co-ordination number vary only slightly with temperature if at all. These directed forces are much more pronounced in the case of triglycerides, which is connected, evidently, with the complex structure of their molecules, composed of glycerol with three fatty acid chains. Accordingly, the co-ordination number of liquid tryglycerides is greatly dependent upon temperature.

In order to express the dependence of activation energy B on the degree of unsaturation in a representative manner, the values of B were plotted in Fig. 2 as a function of iodine number (see the sixth column in the table) for a number of fatty acids with eighteen carbon atoms.

From the table and Fig. 2 it will be obvious that the activation energy B decreases quite regularly with the increase of iodine number, and, consequently, of the degree of unsaturation of the fatty acids. It is to be inferred from that fact that the co-ordination number increases with the increase of iodine number. It may be concluded further that the heats of melting of fatty acids should exhibit the same kind of dependence upon iodine number as that shown in Fig. 2. The values of the heat of melting in Cal./mol. are given in the fourth column of the table for some fatty acids according to the data, taken from the reference book of the All-Union Research Institute of Fats ([14]), and for hydrogenated oil, according to the data quoted by M. B. Ravich ([15]) and I. M. Towbin ([16]). The relation between heat of melting and the activation energy B for the substances, for which L is known, turns out to give $L > B$ in our case, which is quite unexpected, since the reverse, namely

* Thus, for instance, we examined the applicability of Bachinsky formula to oleic acid.

$L < B$, with but few exceptions was obtained by Ward. Taking $B/L \approx 0.5$ as it is the case with stearic and palmitic acid (see the fifth column in the table), we will obtain the following values of molecular heats of melting for the other fatty acids: oleic acid—11.4 Cal./mol., linolic acid—10.3 Cal./mol., linolenic acid—9.6 Cal./mol.

As regards the triglycerides, it is difficult to arrive at definite conclusions about their heats of melting, because of a lack of experimental data. It might be assumed, neverthelless, on the basis of values B obtained that the heats of melting of all triglycerides cannot possibly be very different from one another. From the value given in the fourth column of the table, we may suppose them to be within 30—40 Cal./mol. The value L is greater for tristearate than for tripalmitate, while it is the least for trioleate.

It ought to be mentioned that the X-ray study, to which we are now subjecting the fatty acids and triglycerides ([12]), makes it possible to ascertain the values of their co-ordination number and the character of the forces acting between the molecules.

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GEOCHEMISTRY

WEATHERING OF JAROSITES

By F. V. CHUKHROV

(Communicated by A. E. Fersman, Member of the Academy, 16. III. 1939)

As shown by recent investigations, jarosites (both potash and soda variety) are minerals most common for the weathering zone of those sulphide deposits, which are characterized by the presence of more or less considerable segregations of pyrite in the composition of primary ores. In particular, investigations carried out by the author in Central Kazakhstan have shown the wide development of jarosites in the deposits of this region. Jarosites were encountered in the following individual deposits: Stepnyak, Stalinskoye, Djelambet, Danilovskoye, Maikain, Aleksandrovskoye, Kazanauz, Perun, Djangabul, Berkara, Kounrad, etc.

Genetically, the jarosites represent typically hypergenous minerals. Their being confined to deposits to a certain degree enriched with pyrite. is accounted for by the fact that the jarosites are formed and exhibit lasting stability only in acid solutions, the formation of which accompanies, as a rule, the weathering of pyrite.

The presence of jarosites among the products of hypergenesis points to pyrite (rarely pyrotite) being contained in the sulphide ores. Moreover, according to the nature of the wall-rocks, there is formed either the soda, or the potash variety of jarosite. Thus, by the nature of the jarosite one may form an idea of the character of the wall-rocks, those being almost the only source of alkaline metals fixed in the jarosites.

As the development of the weathering zone of sulphide deposits has a trend towards the increase of the pH of the solutions, it is natural that when approaching the ultimate stages of hypergenesis, the jarosites are found to be unstable and to undergo hydrolytical splitting. As shown by our observations in Central Kazakhstan, the products of a direct alteration of jarosites very often are ironstones with a haematite crystalline phase, while hydrogoethite ironstones are less frequently formed immediately after jarosites and particularly in those cases when the amount of weathering jarosites is small.

At the initial moments of weathering jarosites usually acquire a reddish colour, corresponding to the presence of a haematite substance, probably in the form of hydrohaematite. It is typical that in the course of time ironstones with a haematite crystalline phase pass into brown ironstones, the base of which is constituted by hydrogoethite. The intermediate forms are turgites, which are considered as fine mechanical compounds of hydrogoethite and hydrohaematite.

The most illustrative is the weathering of jarosites in Maikain (the Bayanaul region of the Pavlodar district), where the jarosites are represented only

by large accumulations, especially in the «C» deposit. Judging by the data of shaft sinking, jarosites are encountered at the depth of 30—35 m from the surface. On the 40 m horizon exposed by underground workings, the jarosites are observed in different stages of replacement by iron oxides, as well as independent, occasionally considerable accumulations of ironstones, formed after jarosites. Hydrogoethite ironstones are not unfrequent here, but they are not observed as products of a direct replacement of jarosites. The most common products of the transformation of jarosites are turgite ironstones, while hydrohaematite are of rarer occurrence.

On the 50 m horizon early stages of jarosite weathering are observed. No considerable accumulations of ironstones, especially of hydrogoethite ones, have been encountered on this horizon. In the ore bodies, exposed by quarries from the surface, the ironstones are represented almost exclusively by hydrogoethites, morphologically not differing from hydrogoethite and turgite ironstones of the 40 m horizon. In the deposit the passage from hydrohaematite and turgites to hydrogoethites is the more clearly observable, the nearer the surface. This points to a successive passage from younger to older products of jarosite weathering, the former being less rich in water.

It would be of considerable interest to find out to what an extent the above trend of jarosite weathering may be considered as universal. As examples of deposits of the Central Kazakhstan, in which such a nature of transformations has been observed by the author, may be cited the Kounrad, Borly, Berkara, Taukin and Stalinskoye deposits. Outside Kazakhstan, the replacement of jarosites by red-coloured iron oxides has been observed by the author also on the Kerch peninsula in the Novo-Karantinny mine. Pilipenko [1] has described the replacement of jarosite by turgite from the Krukovsky mine in the Altai. In the Petrovsky mine in the Altai, where jarosite is represented by insignificant segregations, according to the data of the same author, this mineral passes upon weathering into brown ironstone.

The cause responsible for the above-described tendency of the jarosite weathering lies, in the author's opinion, in the high concentration of ferric oxide in those solutions which impregnate the weathering jarosites. Being empirical, such an explanation seems to us to be valid for the correlations observed in nature. It discards the influence of a specific nature of the primary material and of the pH, basing on the formation of turgite ironstones in the course of weathering of siderites in the South Ural deposits, described first by Samoilov [3] and recently by Rylovnikova [2]. Nikitin [5] was the first to point out the relation between the formation of the Ural turgites and the high concentration of ferric oxide in solutions. This author has, moreover, assumed that the presence of some or other dissolved salt in the solutions may also affect this process. This assumption, however, still lacks experimental evidence. The transformation of turgites, formed in the course of weathering of siderites, into brown ironstones (hydrogoethites) was described by Samoilov [3,4].

The nature of weathering of jarosites, cleared up in the present paper, should be taken into consideration when carrying on search and prospecting work under the conditions of Central Kazakhstan.

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PEDOLOGY

ABSORBING COMPLEX OF SOIL—A PARAGENETIC SYSTEM OF (COLLOIDAL) MINERALS

By I. D. SEDLETZKY

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1. The soil colloids represent the most active part of the soils. They compose the absorbing complex (A. C.) of soil which determines many physico-chemical properties of the soils, their fertility and productivity (1).

2. Up to recently it has been quite unknown what kind of compounds compose the absorbing (colloidal) complex. Owing to the absence of a direct method of studying the composition and structure of soil colloids, all the conclusions as to the real character of the compounds constituting the absorbing soil complex have been derived from indirect and chiefly chemical or colloid-chemical investigation. This could not but give rise to different theories as to the absorbing complex of soils and to conflicting opinions as to the nature of the constituents the latter is composed of.

3. The soil colloids were formerly regarded as zeolites and later on as an indefinite mixture of oxides and hydroxides of silicon, aluminium, iron, etc.

Some theories have been refuted by subsequent investigations. The theory of a zeolite composition of the absorbing complex has been entirely overthrown (Glinka). It should be noted, however, that lately some West-European scientists, e. g. Vageler (3), returned to the old false opinions rejected by modern science and interpreting the absorbing complex as a zeolite complex, in spite of the fact that recent advances in soil science in the field of study of soil colloids give abundant and irrefutable evidence as to the absence of either zeolites or permutites in the absorbing complex.

4. Let us pass now from conjectures and indirect conclusions concerning the composition and structure of the absorbing complex to a direct investigation of the soil colloids and of the compounds they are composed of. The X-ray analysis permitted us at last to pierce into that world which hitherto escaped the eye of the investigator—the world of superfine particles from 10^{-4} to 10^{-7} cm in size. This is the world of colloids, whose general properties have been so thoroughly studied by the method of colloidal chemistry, but whose inner nature up to now remained obscure.

5. Since the first works of Hendricks and Fry (4), who have been the first to apply the X-ray phase analysis to the study of the colloids of American soils, it became evident that the soil colloids are crystalline compounds and consist of clay minerals. During the eight years which passed since then, an extensive study has been made of the principal types of colloids of the soils of the whole world: Kelly, Dore and Brown, Grimm, Kerr and

others studied the soils of USA; Antipov-Karataev, Rode, Sedletzky etc.—those of the USSR; Jacob, Correns, Hoffmann etc.—those of Europe, Africa, Asia Minor, some islands of the Mediterranean Sea and the oceans; Kavamura—those of Western Japan etc. [see the author's monograph (5)].

The results of numerous investigations of the soil colloids by X-ray and thermic methods (5) showed that the inorganic colloids of the soils from different countries are composed of clay minerals. The principal of these are as follows: montmorillonite (Ca,Mg) ($O.Al_2O_3.4—5SiO_2xH_2O$), beidellite ($Al_2O_3 \cdot 3SiO_2 \cdot xH_2O$), nontronite ($Fe_2O_3 \cdot 2SiO_2.2H_2O$), halloysite ($Al_2O_3$. . $2SiO_2.4H_2O$) , kaolinite, dickite, nacrite (Al_2O_3 .$2SiO_2$. $2H_2O$) etc.

6. Thus, the X-ray analysis showed that the absorbing complex of soil basic portion mainly consists of a number of aluminosilicates of individual character, possessing their own particular chemical composition and specific crystalline structure. In the same way is solved the question as to the absorbing soil complex and its constituents. Consequently, neither zeolites nor their permutoid analogues are present in the colloids of soils.

Thus, the absorbing complex of soil is no «conglomerate»(2), but it consists of certain minerals, which are present in a highly disperse colloidal state. From their composition the minerals of the soil colloids are organic, inorganic and organomineral.

From their state they may be crystalline, amorphous and metastable. These minerals are produced in the course of soil-formation process and are soil minerals (pedolites). The composition of pedolites in each soil is therefore not accidental, but depends upon the origin of the soil. The absorbing soil complex is a paragenetic system of pedolites.

7. Different soils are the result of different soil-forming processes. On the basis of the fundamental statements of Dokuchaev, who considers soil as a specific natural body and the reactions proceeding therein as being of specific nature, we must admit for soils in general and for each type of soil in particular the formation of individual characteristical groups of minerals.

The colloids of soils, as the finest and most active part of soils, should reflect most fully all the variations of the soil-forming processes they result from. It is in the absorbing soil complex that the colloidal minerals (pedolites) characteristic of each type of soil must be concentrated.

The studies of the composition of the colloidal minerals of the principal soil types, carried out in the USSR during the last years, which have been made chiefly in the Institute of Soil of the Academy of Sciences of the USSR, partly by the author, under the guidance of Antipov-Karataev, actually confirm the existence of such groups of pedolites characteristic of different types of soils. It becomes most conspicuous in the inorganic portion of the absorbing complex, which is the more thoroughly studied. We give in Table 1 the composition of the minerals of colloids for some types of soils of this country subdivided into minerals of the parent rock (detrites) and minerals of soils (pedolites).

As may be seen from the data of Tables 1 and 2, the pedolites typical of soils of the alkali soil series are as follows: gedroycite, montmorillonite, beidellite, muscovite etc., while soils of the podzol series are characterized by the presence chiefly of minerals of the kaolin group (kaolinite, dickite, nacrite), quartz, limonite etc. This fully coincides with the hypothesis (9) previously (1936) advanced by us, that the pedolites of the kaolin group point to the acid soil-formation process, while those of the montmorillonite group are typical of the alkali soil series*.

* In 1937 Kelly and Dore (10) expressed the opinion that the character of the soil minerals depends on the reaction of the medium.

Table 1

Composition of Pedolites as Dependent on the Types of Soil-Formation

Type of soil	Horizons in cm	Composition of colloid minerals	Minerals of parent rock	Soil minerals (pedolites)
1	2	3	4	5
I. Soils of the series: salt march—alkali soil—alkali soil transformed into steppe soil—chestnut soil (left bank of the Volga)				
1) Sulphate-chloride	0—5	beidellite muscovite	— —	beidellite muscovite
	10—15	beildellite	—	beidellite
	18—23	»	—	»
	25—30	nacrite *x*-mineral	nacrite	—
	210—220	biotite kaolinite	biotite kaolinite	—
2) Soda alkali soil—salts march	0—3	montmoril.	—	montmoril.
	5—10	»	—	»
	10—15	beidellite	montmoril.	beidellite
	20—25	»	»	»
	45—50	montmoril. beidellite	»	montmoril. —
	195—200	»	»	beidellite
3) Alkali soil transformed into steppe soil	0—5	montmoril.	—	montmoril.
	5—10	»	—	»
	15—20	»	montmoril.	»
	40—45	»	—	»
	124—129	»	—	»
	195—200	»	—	»
4) Chestnut soil on the Syrt clays of the left bank of the Volga (7)	0—8	montmorillo-nite muscovite	—	montmoril. muscovite
	14—30	montmorillo-nite muscovite *x*-mineral	montmoril. muscovite	montmoril. muscovite *x*-mineral
	67—77	montmorillo-nite muscovite	—	montmoril. muscovite
	370—335	montmorillo-nite muscovite	—	montmoril. muscovite
II. Soils of the podzol series (Leningrad region)				
5) Humus—highly podzol soil on bandy clay (8)	5—10	quartz nacrite montmoril.	— — montmoril.	quartz nacrite —
	30—35	quartz halloysite montmoril.	— — montmoril.	quartz halloysite —
	60—65	quartz dickite montmoril. muscovite	— — montmoril. muscovite	quartz dickite — —
	100—105	halloysite limonite montmoril. muscovite	— — montmor. muscovite	halloysite limonite — —

Table 1 (continued)

Type of soil	Horizons in cm	Composition of colloid minerals	Minerals of parent rock	Soil minerals (pedolites)
1	2	3	4	5
III. Soils of the red soil series				
7) Red soil of the western slope of the Adzhar Range (podzolized)	0—5	quartz kaolinite limonite beidellite	— — — beidellite	quartz kaolinite limonite —
	50—60	kaolinite beidellite	— beidellite	kaolinite —
	90—100	kaolinite beidellite	— beidellite	kaolinite —
	390—400	»	»	—

The alkaline soil-formation process being substituted by the process of malting, characterized by a neutral and slightly acid medium, results in the appearance of kaolin minerals and quartz which is well illustrated by the alkali soil chernozem series of the soils (Table 2).

Table 2

Evolution of Soil and Dynamics of Pedolites

Type of soil	Depth of sample taken in cm	Minerals of soil colloids		Minerals of alkali soil (I stage)	Minerals of malted chernozem (II stage)
		fraction 2—0.2 μ	fraction <0.2 μ		
Soils of the series: alkali soil—malted chernozem (Chernigov region)					
8) Soda alkali soil on loess	0—0.5	montmoril. sericite	montmoril.	montmoril. sericite	—
	0.5—10	gedroycite	montmoril. muscovite	gedroycite montmoril. muscovite kerolite	—
	24—34	kerolite	Mg-beidellite	montmoril. Mg-beidellite	—
	40—70	kerolite	kerolite montmoril.	kerolite montmoril.	—
	190—200	montmoril. kerolite	montmoril. —	montmoril. kerolite	—
9) Malted chernozem on loess	35—45	quartz halloysite biotite	halloysite	— biotite	halloysite quartz
	55—65	halloysite kerolite	halloysite boehmite	— kerolite	halloysite boehmite
	115—125	—	beidellite meta-quartz	beidellite —	meta-quartz
	190—200	—	beidellite	beidellite	—

In soda alkali soil are present chiefly montmorillonite and muscovite, while in the malted chernozem appears also halloysite. Sericite, kerolite and other minerals of malted chernozem are residual minerals, characteristic of the alkali soil stage, experienced by the malted chernozems. The presence of montmorillonite (which is characteristic of alkali soil and of alkaline conditions of weathering) in number of other chernozems and in the podzol soils of the north points to the initial swamp-meadow stage of development of these soils. It is probable, however, that the origin of the montmorillonite of the podzolized soils, e. g. of the Leningrad region, is connected with the formation of soil-forming parent rocks (bandy clays) under alkaline conditions (Table 1).

In the course of the podzol-formation process the clay minerals of bandy clays (montmorillonite, muscovite etc.), gradually disintegrate and are replaced by new minerals (kaolinite and quartz) in the soil horizons.

8. From the above it may be seen that the composition of pedolites of different soils is not the result of a casual combination of minerals. On the contrary, a quite definite, natural paragenetic association of minerals, regularly distributed over the genetic horizons, corresponds to every soil. The minerals of the absorbing soil complex are composed chiefly by minerals formed under conditions of the modern soil-formation. But in accordance with the genetic conditions and the history of formation of the given soil, its absorbing complex may contain detritic minerals either of the parent rock or of individual soil-formation stages, experienced by the soil in the course of its evolution.

The properties of the absorbing soil complex (and therefore also of the soils themselves) vary according to the character of mineral association. The exchange capacity, the non-exchange condition of cations, the accessibility of cations and anions to the plant, and in some cases even the composition of exchange cations and other properties of the absorbing complex depend on the composition of the pedolites.

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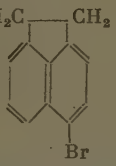
GENETICS

BROME-ACENAPHTHENE AND BROME-NAPHTHALINE AS AGENTS INDUCING CHROMOSOME DOUBLING IN RYE AND WHEAT

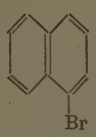
By A. SHMUCK and DONTCHO KOSTOFF*

(Communicated by N. I. Vavilov, Member of the Academy, 27. II. 1939)

After the discovery of the biologically active properties of the substance acenaphthene ([1–3]) the particles of which induce chromosome doubling, a series of polycyclic condensed carbohydrates were tested. Among them two substances, namely, 5-brome-acenaphthene and α-brome-naphthaline, were found to induce in germinating seeds of rye and wheat reactions similar to those induced by polyploidizing agents, colchicine and acenaphthene. These two substances suppress the growth of the seedlings, the roots remain short, but thicker, especially at the ends (Fig. 1), forming tumour-like swellings with abnormal mitosis.



5-brome-acenapthene
(melting point 52° C)



α-brome-naphthaline
(boiling point 280° C)

There are no difficulties in obtaining these two substances; brome-acenaphthene can be produced by direct bromification of acenaphthene in ether solution ([4]), in chloroform solution ([5]) or in alcohol solution ([6]), α-brome-naphthaline can also be produced by direct bromifying of the naphthaline ([7]).

The procedure of the production processes is as follows:

1. Production of Brome-Acenaphthene (after Graebe). Five grams of acenaphthene are dissolved in 25 cm³ chloroform and to the boiling solution drops of 5.3 g brome dissolved in 10 cm³ chloroform are gradually added stirring the mixture. After the reaction is ended, the chloroform is evaporated and the residue is several times recrystallized from alcohol.

2. Production of Brome-Naphthaline. Twenty three grams of naphtaline are mixed with 25 cm³ hot water and then stirring 29 g of brome are gradually added, the temperature being kept at 40—50° C. After the reaction is ended, the floating layer is separated in a retort and heated in an oil bath at a temperature of 150°C, blowing into the retort dry

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water vapour. The remainder in the retort is further fractionally distilled in vacuum, collecting the fraction boiling at 132—135°C (12 mm).

In order to test the activity of 5-brome-acenaphthene and α-brome-naphthaline the substances were dissolved in ether, desired quantities were dropped on blotting paper placed in Petri dishes and, after the evaporation of the ether, seeds were germinated in these dishes on blotting paper, the latter being wetted with tap water.

When tested on germinating seeds of wheat and rye, the following concentrations of these substances proved biologically active:

Amounts per Petri dish in mg	5-brome-acenaphthene	α-brome-naphthaline
50	Typically strong positive reaction	Seedlings perished
20	Do	Part of the seedlings died
10	»	Typically strong positive reaction
5	»	Do
2	»	»
1	»	»
0.5	»	Weak reaction
0.2	»	» »
0.1	»	Normal development

Since under similar conditions the smallest amount of acenaphthene that gives a positive reaction is 0.3 mg per Petri dish ([8]), brome-acenaphthene is a stronger (more potent) agent in this respect, while brome-naphthaline is somewhat less potent than acenaphthene.

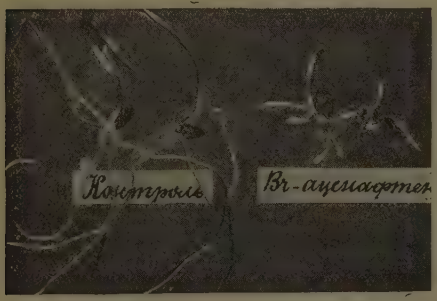
Both 5-brome-acenaphthene and α-brome-naphthaline are practically insoluble in water. Their water extracts are practically inactive.

For a more detailed investigation of the deviations in the normal course of the mitotic process induced by 5-brome-acenaphthene, seeds were germinated in Petri dishes which contained the following doses of brome-acenaphthene: 1) 100 mg; 2) 30 mg; 3) 3 mg and 4) 0.3 mg per Petri dish. In each Petri dish were grown seeds of *Secale cereale* and *Crepis capillaris*. In addition to these in the first and in the third Petri dishes were also grown seeds of *Vicia sativa*. Seeds of *Triticum vulgare* germinated in a Petri dish with 5 mg of 5-brome-acenaphthene were also studied cytologically.

Secale cereale seedlings showed typical swelling at the root tips and considerable thickening of the coleoptiles in all four Petri dishes; in the first two they were, however, more pronounced, while in the last one the reaction was weaker. In the first Petri dish the growth was very much suppressed, so that the other three Petri dishes offered a much better material for cytological studies. *Crepis capillaris* and *Vicia sativa* seedlings showed scarcely noticeable swellings in each Petri dish, though *Vicia* seedlings in the first dish had somewhat thicker roots than those in the third dish.

Cytological peculiarities induced by 5-brome-acenaphthene were found in studying the mitotic processes in the root tips of rye and wheat seedlings. They remind of those induced by colchicine and acenaphthene in somatic cells and in pollen mother cells ([2,9–12]). The most striking phenomena observed were the chromosome doubling and the formation of large amoeboid nuclei. Studying various stages of mitosis in a series of preparations, the following anomalies were found. During the metaphase the chromosomes are

not arranged strictly in equatorial plates as this occurs in normal cells, though they show a trend toward such an arrangement. In other words, the picture observed is an intermediate one between a colchicine and a normal metaphase. The achromatic figures are highly disorganized. The processes that secure a proper chromosome arrangement in an equatorial plate and those conditioning the chromosome separation are upset. The chromosomes split, then they divide (their centromeres also divide), but the halves do not move towards the poles, remaining together. Thus, a doubling takes place. Single chromosomes or groups of chromosomes from one side or from



Control Br-acenaphthene

Fig. 1. *Triticum vulgare* seedlings: left—normal (control), right—grown in Petri dish with 5-brome-acenaphthene.

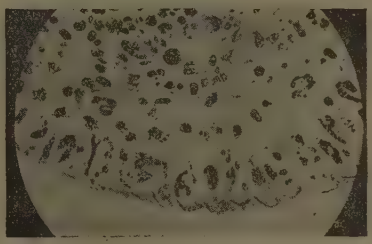


Fig. 2. Transversal section through a root of *Secale cereale* seedling grown 4 days in Petri dish with 3½ mg of 5-brome-acenaphthene.

more than one side begin to penetrate into the cytoplasm (Fig. 2). This results later on in the formation of amoeboid nuclei. When some of the chromosomes which penetrate into the cytoplasm become somewhat separated from the principal chromosome group, a new nucleus is formed near the principal one. The nuclei of the binucleated or multinucleated cells are not equal, since they contain different numbers of chromosomes. During the next mitosis the chromosomes appear in positions determined by the position of the nuclei or of the amoeboid «sacs» of the nuclei. Again they form no strict equatorial plate, though each individual chromosome group tends to do so. The chromosomes split again and divide, but they do not separate, thus forming an octoploid cell, and so on.

In the rye seedlings growing in the above described Petri dishes for four days, we found most frequently tetraploid cells, though diploids and octoploids were also found. A higher degree of polyploidy was rarely found. It should be pointed out here that tetraploidy ($4n=28$) in rye is easy to state, while a higher degree of polyploidy is difficult to determine, because the chromosomes of rye are long and in the treated material they do not become arranged in a proper equatorial plate as they do in normal untreated material.

In studying cytologically the process of mitosis in the root tips of the treated *Tr. vulgare* seedlings, the same cytological phenomena were observed as those in treated rye seedlings. This gives us good reason to class 5-brome-acenaphthene among the very efficient agents inducing polyploidy in wheat and rye.

However, studying the process of mitosis in the root tips of *Vicia sativa* we failed to detect any noticeable anomalies of the kind observed in wheat and rye. Throughout the preparations made of treated *Vicia* roots we found nothing but normal diploid metaphases and normal nuclei. In an almost similar

way behaved *Crepis capillaris*, although some delay in the separation of the chromosomes were noticed and in a few cells chromosome doubling was found. On the basis of these observations we cannot recommend 5-brome-acenaphthene for chromosome doubling in *Vicia* and in *Crepis*.

Secale cereale and *Triticum vulgare* seedlings grown in Petri dishes with 1 mg α-brome-naphthaline per dish were also studied cytologically. We found the same cytological abnormalities as in those treated with 5-brome-acenaphthene (Fig. 3, 4). Cells with doubled chromosomes were very often found.

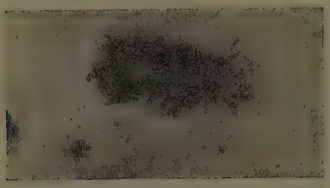


Fig. 3. An octoploid cell from a root tip of *Secale cereale* seedling grown in a Petri dish with α-brome-naphthaline.

Fig. 4. Cell with amoeboid nucleus from a root tip of *Secale cereale* seedling grown in a Petri dish with α-brome-naphthaline.

There were roots, in which it was difficult to find diploid cells. This points to the fact that α-brome-naphthaline can be successfully used for inducing polyploidy in *Secale* and *Triticum*.

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GENETICS

CHROMOMERE STRUCTURE OF THE CHROMOSOME SET OF RYE

By E. N. SHMARGON

(Communicated by N. I. Vavilov, Member of the Academy, 4. III. 1939)

The present work is a continuation of the analysis of the chromomere structure of one of the chromosomes of the rye complex conducted by me earlier (1). Data furnished by this analysis, in connexion with the results of other writers (2, 3, 4), make it possible to draw some general conclusions regarding the structure of somatic chromosomes.

1. When special technique is applied, at certain stages of mitosis differentiation of the chromosome body into individual chromomeres may be observed. Early and late metaphase proved to be most suitable stages for this purpose.

2. Revealing of the chromomere structure does not obstruct the fundamental differentiation of the chromosome, viz., the primary and secondary constrictions.

3. The number of chromomeres is typical of the chromosome as a whole and of its individual portions (limbs, appendixes), too.

The above statements may be of use in establishing the number of chromomeres in any chromosome of a set; this makes the morphological characteristic much fuller, inasmuch as the internal structure of the individual chromosome parts is revealed. The desire to distinguish as many individual chromosome parts as possible is due to certain observations on the rearrangement of the chromosomal segments; and detailed study of them is possible only when their internal structure is known. Here the chromomere structure is a substantial addition to the principal chromosome differentiation. On the other hand, the establishing of the chromomere number in many cases may replace the characteristic obtained from measurements of the chromosome limbs. The technique of chromosome measurements with the aid of the micrometer screw, which has been introduced by Lewitsky (5), is highly valuable owing to its exactitude; however, it is time consuming, and thus imposes limits on the registration of chromosomal variation. Preparation of idiograms may be limited to counting chromomeres in individual chromosomes when typical chromomere structure of each of them is sufficiently known; moreover, such a characteristic may not only furnish a more profound knowledge of the morphological nature of the chromosomes, but would make it possible to notice variation and structural aberrations in them.

The first step in our cytological study of rye was to get acquainted with details of individuality of each chromosome pair with the aid of Lewitsky's

method ([5]). It became possible as a result to recognize «personally» each individual chromosome in any given plate ([6]). Then the chromomere structure of the one chromosome distinguished by the presence of an appendix was repeatedly studied; it was established that the number of the chromomeres of this chromosome is always constant. Its greater limb proved to contain six chromomeres, the small one—three and the appendix two of them; the whole chromosome thus appeared as a chain of eleven linearly arranged chromomeres([1]). Possibility was thus obtained for the analyzing the structural details of all the remaining chromosomes of rye; the established technique ([1]) was applied in later studies.

Chromosomes situated as nearly to the horizontal plane as possible were selected for the study, since it proved to be impossible to establish the exact number of chromomeres in limbs which were bent. Owing to this circumstance, the chromosomes in the majority of cases had to be studied in different plates.

Fig. 1, *a* shows the typical chromosome morphology of this plant in roots fixed with «strong platino-formalin» ([7]) and previously subjected to cold (at 0°) during 24 hours. In Fig. 1, *b*, *c* and *d* is represented the chromomere structure characteristic of each chromosome type. Repeated analysis of each chromosome supported the assumption expressed earlier, viz., that the number of chromomeres is constant and they are definitely distributed in the chromosome limbs. The longest heterobrachial (consisting of unequal limbs) chromosome (Fig. 1, *I*, *b*, *c* and *d*) always contains twelve chromomeres. Eight of them are in the major limb, four, satellites included, are in the smaller limb. The second chromosome (Fig. 1, *II*, *b*, *c*, *d*) altogether contains nine rather large chromomeres which are somewhat pulled apart; six of them are in the greater limb and three in the smaller one. In the third chromosome (Fig. 1, *III*, *b*, *c*, *d*) there are eleven chromomeres; seven of them belong to the greater arm, and four to the smaller one. Sometimes (in three cases out of twelve) in the smaller limb of this chromosome five chromomeres are observed instead of four; the entire chromosome contains correspondingly in such cases twelve chromomeres instead of eleven. Such an increase in number is obviously due to a certain instability of the one of the composite chromomeres of the smaller limb which is subdivided into two chromomeres of simpler structure. All the three chromosomes when studied under application of the ordinary technique simply appear as clearly heterobrachial with satellites on the smaller limbs (Fig. 1, *Ia*, *IIa*, *IIIa*). The fourth chromosome (Fig. 1, *IV*, *b*, *c*, *d*) has thirteen rather small chromomeres. This chromosome consists of nearly equal limbs, and its larger limb contains only one chromomere in excess as compared to the smaller one. The same is true of the sixth chromosome (Fig. 1, *IV*, *b*, *c*, *d*) which consists of eleven chromomeres and of the seventh chromosome (Fig. 1, *VII*, *b*, *c*, *d*) containing nine chromomeres. The fifth chromosome (Fig. 1, *V*, *b*, *c*, *d*) is the one possessing an appendix and has been already described; it similarly contains a constant number of chromomeres. Even in those cases when several chromosomes contain equal total numbers of chromomeres (Fig. 1, *III*, *V*, *VI*), different distribution of the latter enables one to distinguish each chromosome individually.

The present work thus resulted into an analysis of the chromomere structure of all the chromosomes composing the set of rye (*Secale cereale* L.). The results obtained open prospects of further developments in this field; an analysis of the structure of the 16-chromosome rye as well as of other species of rye would be of unquestionable interest.

It should be noted in connexion with the chromomere structure that chromomeres are rather regularly distributed along the chromosome length,

and in the split regions the pairs of chromomeres are absolutely homologous not only with regard to the relative positions of the components, but with regard to their sizes too; this insures constancy of the number and arrangement of the chromomeres within chromosomes of a given plant. We failed to notice any regularity in the reoccurrence of one and the same size of a chromomere. Possibly, the reason consisted in the fact that condensation

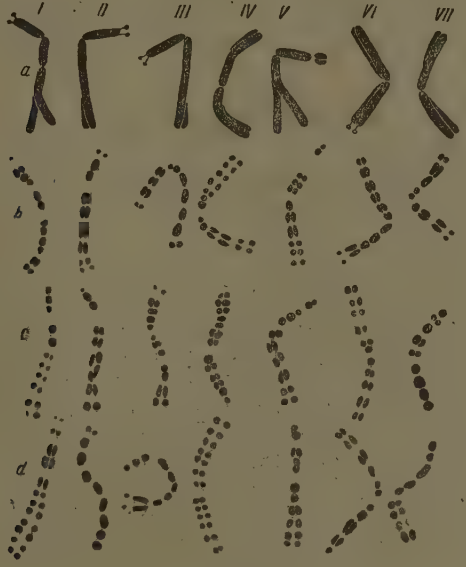

Fig. 1.

of chromatin is insufficiently constant as regards the amount of material accumulated in each individual chromomere. It is possible too, that excessive stain is irregularly differentiated away by alumen; however, the intensity of coloration is equal along the whole chromosome length.

The chromomeres proper are probably compound structures which originate from fusion of several ultimate chromomeres into compound «blocks». We are in accord with other investigators ([3]) that such compound chromomeres are centres of condensation of chromatin. In the present study chromomeres were applied to morphological characteristic of the chromosomes. They appear, too, most interesting with regard to the cell ontogenesis, particularly, to the questions on accumulation and dissolution of chromatin in transformations of the cell nucleus, and to the problem of regular condensation of chromatin, ultimately leading to the emergence of chromosomes possessing definite morphology.

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GENETICS

DISTRIBUTION OF BREAKS IN THE X-CHROMOSOME OF *DROSOPHILA MELANOGASTER*

By A. A. PROKOFIEVA-BELGOVSKAJA and V. V. KHVOSTOVA

(Communicated by N. I. Vavilov, Member of the Academy, 27. II. 1939)

A comparison of the location of «inert» regions in the *X*-chromosome of *Drosophila melanogaster* with the distribution of a number of breaks in that chromosome (inversions y^{3P}, sc^3, sc^4, sc^{s1}, w^{m4}, rst^3, *ClB*, δ49, B^{M1}, B^{M2}, and translocations w^{m5}, w^{mMed}, $w^{m258-18}$ and others) showed that the breaks had occurred rather in the inert regions or in their immediate vicinity. This fact led to the suggestion that the coincidence observed could not be ascribed to a mere chance ([1], [2]). Extensive data on the distribution of breaks in the *X*-chromosome collected by V. V. Khvostova in co-operation with N. P. Dubinin and V. V. Mansurova fully substantiated this suggestion.

A total of 141 breaks in the *X*-chromosome of *Drosophila melanogaster* were located. 30 of these were found among F_1 larvae derived from *ClB* females crossed with X-rayed inbred *forked* males. 4 out of these 30 breaks caused inversions and 26 translocations. The remaining 111 breaks were found in the course of cytogenetic analysis of *X*-chromosome lethal mutations, detected in F_2, 66 out of 111 breaks caused inversions, 30—translocations and the rest—other kinds of chromosomal rearrangement (insertions, deficiencies).

The technique used did not allow the detection of all breaks in the inert region 20 *A*—*F* (near the spindle fibre attachment), the data concerning the frequency of breaks in that region being therefore not complete. Each break was carefully located in one of the 120 sections of Bridges' map.

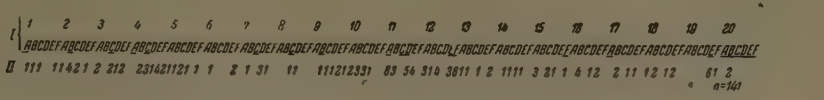
An examination of the distribution of 141 breaks and a comparison of this distribution with that of inert regions along the *X*-chromosome revealed the following facts:

Out of 141 breaks covering the whole lengh of the 20 large sections of the *X*-chromosome, 37 proved to be located within 2 sections: the 11th and 12th, these two including three inert regions—11*A*, 11*CD*, and 12*EF*,—clustered within a rather limited chromosome regions. Out of the 37 breaks located in sections 11th and 12th, 8 were found to occur just in the inert regions 11*A* and 9 in the inert region 11*D*, or in its immediate proximity—in the region 11*E*.

The next group of breaks including 6 breaks occurred in the inert region 19*E*. The remaining breaks are more or less evenly distributed throughout the whole length of the chromosome, being somewhat more numerous in or near the inert regions 2*B*, 4*C* and 7*C*.

The number of breaks studied being relatively small (as compared with the total number of chromosome sections the breaks were located in), the probability of a chance occurrence of many breaks within just one section is so small, that for case of coincidence of 6 and more breaks it may be completely neglected.

Thus, the probability of chance occurrence of 6 breaks within one section is 0.00105 (i. e. $^1/_{1000}$), and that of 8 breaks is only 0.00002 (i. e. $^1/_{50000}$) A chance coincidence of 5 breaks is not excluded, but very improbable (its probability being 0.0055).



I. Divisions of the Bridges map («inert» regions underlined).
II. Number of breaks.

It follows that the data collected constitute a proof of a non-random distribution of breaks leading to chromosomal rearrangements. Although a chromosome can be broken in any point, the breaks in the inert regions are relatively much more frequent than in the active ones. It is necessary to point out that this is true not only of the terminal inert regions [the proximal and the distal one ([3])], but of the interstitial ones as well.

The conclusion we have arrived at agree neither with that of Kaufmann and Demerec ([4]) nor with the conclusion of Bauer, Demerec and Kaufmann ([3]). At least one of the causes of this disagreement lies in the methods used. The authors mentioned above located the breaks they studied less accurately than we did—within one of 20 large sections of Bridges' map instead of locating each break within one of 120 small subsections this map includes. As the interstitial inert regions of the *X*-chromosome correspond to the small subdivisions of Bridges' map and not to the large ones, Bauer, Demerec and Kaufmann could not reveal the specific breakability of these inert regions. The higher breakability of the sections 11th and 12th is nevertheless evident from their own data. Their data showing higher breakability of both terminal (proximal and distal: the 1st and the 20th) regions, where inert regions are also clustered, are in a complete agreement with our conclusions.

The chromosome of the interstitial inert regions of the *X*-chromosome and of its distal inert regions 1*A*123 has the same srtucture as that of the inert regions 20*A*—*F* situated near the spindle fibre attachment. Its chromioles form slender, continuous or interrupted discs, characteristic of all the «inert» regions described: 1*A*1—3, 2*B*, 3*C*3, 3*C*6, 4*A*5—6, 4*C*3—7, 7*C*, 8*C*, 9*B*, 11*A*, 11*CD*, 12*EF*, 15*F*, 17*A*, 19*E*3—4, 20*A*—*F*.

The most obvious cytological peculiarity of the inert regions is their capacity of conjugating with one another. This is true not only of whole inert regions, but of separate discs of inert region as well, when they have been brought apart by a break. The last feature is especially well expressed in the proximal inert region 20*A*—*F*.

Two hypotheses can be put forth in order to explain the capacity of inert regions and their parts to conjugate with one another:

1. Inert regions are specialized sections of a chromosome, all or most of their loci being more or less homologous to one another (multiplications). The mechanism of conjugation of «inert» regions is fundamentally the same as that of conjugation of the «active» ones (Muller, Prokofieva).

2. Conjugation of inert regions with one another is a phenomenon of a non-homologous conjugation of chromosomes, fundamentally different from the conjugation of homologous sections of active regions (Bauer).

Although no direct proof of any of these hypotheses is now available, the authors are inclined to considered the former more plausible.

It seems very probable that the conjugation of inert regions can be responsible for the occurrence of chromosome rearrangements. But the hypothesis that inert regions have a specific physico-chemical structure this causing their relatively high breakability, as compared with other chromosome regions irrespective of their conjugation with one another, is not excluded either.

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PLANT PHYSIOLOGY

COMPARATIVE STUDY OF THE REQUIREMENT OF FUNGI FOR GROWTH SUBSTANCES B

By A. VERNER and A. TIURINA

(Communicated by A. A. Richter, Member of the Academy, 23. II. 1939)

The requirement of fungi for growth substances B has continued to be the subject of a number of investigations within recent years ([11], [3], [7], [2]). The data obtained by different workers are, however, conflicting. N. Nielsen ([6]), Schopfer ([11]) and Kögl ([4]) have reported a positive action of those substances on some of the fungi, while other fungi have been found by them to be indifferent to such action. This statement is not always corroborated ([8]) and sometimes is even refuted ([3]).

The contradictory nature of the results obtained should be ascribed to the procedure used by most of the workers rather than to the heterogeneity of the initial agents studied; in the majority of cases the methods applied conflicted with the well established data on the nature of the formation of growth substances by a heterotrophous organism. Nielsen, Kögl and Ronsdorf express the requirement of fungi for growth substances B in terms of the amounts of dry matter stored up by the fungus; no account is taken thereby of the amount of contagious matter introduced into the substratum. However, the evidence furnished by the same investigators ([4], [6]) is that an organism responding positively to B substances may at the same time act as their source and store them up in substratum. The response of the fungus is dependent upon how far its requirement for growth substances B exceeds its power to form them, and while this requirement may be sharply expressed at the first period of multiplication of the organism, it may later be levelled by the accumulation of growth substances in the substratum if the culture of the fungus in a given medium is continuous over a considerable length of time.

In the experiment here reported the requirement of fungi for growth substances B at the first period of development was estimated from the interval elapsed until the growth of spores seeded in varying numbers became visible. The investigation involved a number of sporophytic and semiparasitic fungi differing in their biology and relation to higher plants.

The fungus spores were seeded in a modified liquid medium of Waxmann* into test-tubes, each of the tubes containing 5 cm^3 of the medium. One set of the test-tubes contained in the medium a bios preparation from yeast purified in alcohol and diluted in water to 0.5%; in the tubes of another set there were no growth substances in the medium. All test-tubes were seeded

* Glucose 10.0; NH_4NO_3—5.0; KH_2FO_4—1.0; $MgSO_4$—0.5; distilled water—1000.0.

with decreasing concentrations of fungus spores, which were obtained preliminarily in a parallel set of test-tubes with tap water. The number of dilutions was determined by the aim to obtain a minimum concentration of spores in one of the extreme test-tubes of the set.

The cultures were grown at 27—30° C; observations were made every day. There was recorded the time when the growth of the fungus became visible under the microscope as well as the further development of the culture. The data on the rate of growth are summarized in the table for spores of different fungi. The figures denote the number of days elapsed from the inoculation until growth appeared under the microscope. The subsequent microscopical observation of the growing cultures failed to detect any morphological differences between the experiment and the control, though the growth of the fungus was slower in the medium destitute of growth substances. It is only the delay in or absence of sporification which may be here noted respecting the fungi requiring growth substances in substratum.

All the fungi tested were taken from the strains collected in the University Museum. The non-identified species of *Aspergillus*, *Trichoderma* and *Alternaria* presented forms isolated from soil.

Concentration of spores in decreasing order	*Aspergillus niger*		*Trichoderma* sp.		*Alternaria* sp.		*Aspergillus* sp.		*Fusarium Solani*		*Fusarium graminearum*		*Verticillium albo-atrum*		*Verticillium dahliae*		*Aspergillus oryzae*		*Botrytis cinerea*	
	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**
I . . .	3	3	3	3	3	3	3	3	3	3	4	4	3	3	3	3	5	5	4	No growth appears for a month
II . . .	3	3	3	3	3	7	3	6	3	4	4	5	3	5	3	6	5	10	4	
III . . .	3	3	3	3	3	7	3	6	3	5	4	7	3	5	3	12	5	10	—	
IV . . .	3	3	3	3	3	7	3	6	3	5	4	9	3	5	3	12	5	10	—	
V . . .	3	3	3	3	3	7	3	6	3	5	4	—	3	8	3	16	5	14	—	
VI . . .	3	3	3	3	—	—	3	8	3	—	4	9	—	—	3	16	5	14	—	
VII . . .	3	3	3	3	—	—	3	8	3	—	4	—	—	—	3	28	5	14	—	
VIII . . .	3	3	3	3	—	—	—	—	—	—	4	—	—	—	—	—	5	14	—	
IX . . .	3	3	3	3	—	—	—	—	—	—	4	9	—	—	—	—	5	14	—	
X . . .	3	3	3	3	—	—	—	—	—	—	—	—	—	—	—	—	5	16	—	

As is seen from the table, the rate of growth of some of the species is dependent upon the presence of growth promoting substances in the substratum and the amount of spores seeded. The saprophytic forms *Aspergillus niger* and *Trichoderma* sp. are distinguished by their growing with equal speed regardless of the presence or absence of growth substances B. With the exception of these indifferent species, all the other fungi should be accounted requiring growth substances for their growth. This requirement is especially conspicuous in *Verticillium dahliae*, *Fusarium graminearum*, *Aspergillus oryzae* and *Botrytis cinerea*; in the first three of them the appearance of growth is delayed for 10—20 days when growth substances are absent from the substratum; the growth of *Botrytis cinerea* does not appear under these condi-

* Medium with growth substances B.
** Medium without growth substances B.

tions for a period of more than a month. Taking into consideration the pathogenic nature of *Botrytis cinerea* and the analogous results obtained by Mosher (5) for a pathogenic fungus *Trichophyton interdigitale*, we may suppose that the growth substance requirement of obligate parasitic fungi is greater still. Experiments along this line are in progress.

A characteristic point to note here is the dependence of the rate of growth of the fungi upon the number of spores seeded. As it may be seen from the table, the rate of growth may become independent of the presence of growth substances when the amount of spores introduced into the substratum is great enough. If, for instance, we were to take that a spore was seeded in extreme dilution for *Vert. dahliae* and that this spore required a period of 28 days for showing growth in a medium destitute of growth substances, then an introduction, into the same volume of medium, of 10^6 spores should call forth the same rate of growth as in the case of a bios preparation being introduced in the substratum. One of the present authors (1) and Schopfer (10) have detected the presence of growth substances B in the fungus spores, which fact is worth further investigation.

Special interest of the data on the rate of fungus growth referred to here lies, however, in their bearing upon the growth of a causal agent in an infectious drop, which has of late been emphasized by Suchorukov (9). It will be obvious that the rate of purely saprophytic growth of the causal agent during the first period of infection is dependent upon the content of growth substances in the infectious drop and the amount of contagious matter in it.

We reach the following conclusions:

1. The fungus species vary in their response to the presence of growth substances B in the substratum. The saprophytic forms are slightly sensitive or even indifferent to these substances; in the parasitic forms the growth substance requirement is bound up with the specialization of the causal agent.

2. Fungus spores may present a source of growth substances B and this circumstance is a factor in the rate of growth of an organism within a synthetic medium, which becomes dependent upon the proportion of seeding. Growth substances B should be credited to play an essential rôle at the first period of fungous infection of a higher plant.

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PLANT PHYSIOLOGY

SOAKING OF COTTON SEED IN BORIC ACID AS A MEANS GOING TO SATISFY ITS BORON REQUIREMENT AND INCREASE SALT RESISTANCE

By V. A. NOVIKOV and R. O. SADOVSKAJA

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Cotton refers to the plants which are distinguished by their high boron requirement. Among the 60 plants tested by Eaton (5) cotton has been found to exceed all the others in the need of boron. And besides it being exigent of, it is also very resistant to boron if the latter is applied in high concentrations, which for other plants turn out to be toxic. Imperative as this need is, it can, however, be satisfied with rather small absolute values of boron.

To meet the demand of cotton plant for boron by soaking its seed in boric acid previous to planting seemed therefore a feasible procedure. We expected the seed to absorb in that way such amounts of boron, as would more or less fill the need of the plant in this element. But it should be expected also that the amount of boron absorbed by the seed might possibly produce a toxic effect especially at the early periods of development. We had, therefore, to choose such concentrations of the acid that the amount of boron taken in by the seed would by no means prove poisonous to the plant at the first periods of its life.

The technique of fertilization with boron would be rendered much easier, if the latter could be supplied to the plant through the seed, not by introduction into soil. Cases also would be eliminated where the effectiveness of the boron in some soils is low, on account of its compounds having changed into forms unavailable to the plant. That such changes actually occur, may be inferred from the fact that in the years following the introduction of boron the latter fails to produce residual effects, though it is present in soil. Agulon's (1) opinion is that borates in soil are converted into insoluble salts. When protective colloids are available in soil, the sparingly soluble borate compounds can readily turn into colloidal condition. Heavy metals, as iron, aluminium, lead, also convert borates into compounds which are scarcely available to the plant (13). Bobko and co-workers (3) believe too that «where lime is in excess in soil, the plant is deprived of the possibility to take up boron».

The physiological rôle of boron has been investigated by Shestakov, Syvorotkin (11) and Shkolnik (12). They point out that this element, when available in nutrient solution, is apt to reduce the uptake of mineral salts. In the experiments of Novikov (7, 8) the presence of boron markedly reduced the uptake of chlorine by cotton plant seedlings. The result was an increased resistance of the plants to salts. The salt resistance was induced by soaking the seed in boric acid. The work of Novikov, carried on in 1934, was not

brought to an end: neither the concentrations of the acid nor the data of soaking were definitely established. This prompted us, in studying the question whether the boron requirement of cotton may be satisfied by soaking its seed in boric acid, to attempt to clear up another point too, that of the influence this procedure exerts upon plant's salt resistance.

The latter varies as the plant grows (9). During early periods of development cotton is especially sensitive to high concentrations. Its salt sensitivity is then greatly dependent upon its ability to absorb salts. The salt resistance of non-halophytes in general is determined by how far they are able to protect themselves from pervasion by excessive salts (10). The same is true of cotton (6). Therefore, if the effect of boron is actually to reduce the uptake of salts, it may be successfully used as a means for increasing the yield of a cotton growing in salty soils.

In the experiments of the preceding years the soaking of cotton seed in 0.1% boric acid failed to produce any effect. Now in choosing adequate concentrations of boric acid, we aimed therefore to call forth a certain depression in the seed treated, but not to such an extent as to affect their germination appreciably. The experiments on the germination of seed soaked in boric acid of varying concentration had shown that the effect desired is produced by concentrations amounting to 0.4% and higher.

We decided to run our experiment with 0.4 and 0.7% boric acid. Portions of seed, 40 grains each, were soaked in beakers with 200 cm^3 of solution at 25° C during 48 hours. The control was soaked in distilled water. In the tests we used American cotton, variety 2034 bred at the Central Selection Station of the All-Union Institute for Chemical Industry. The soaked seeds (13. V. 1938) were planted in Wagner containers of a capacity for 20 cm^3 of absolutely dry soil. The humidity of soil throughout the experiment was 60% of its total moisture capacity. The soil to fill the containers was taken from the upper horizon of a last year plowed land in the experimental fields of Tashkent Agricultural Institute and received added nutrient qualities by fertilization. Per 20 cm^3 of absolutely dry soil there were introduced 6 g of N as $(NH_4)_2SO_4$, 9 g of P_2O_5 as double superphosphate and 1 g of K as KCl. Nitrogen was applied at three different times: 1 g while filling the container, 3 g on budding and 2 g at the outset of flowering. Phosphorous was given 4 times: 3 g on filling the vessels, 2 g on budding, 2 g at the outset and 2 g at the mid-point of flowering. Potassium was introduced at once, while filling the vessels. The experiment was run against two backgrounds: salty soils and non-salty soils. Salting of soil was done after the seedlings appeared above ground, by means of Vant Hoff—Richter's (10) balanced solution and so as to increase the chlorine concentration of the soil solution up to 0.2 of the normal one. Each of the experimental variants included three sets.

There was no essential difference in the time, when the principal phases of development set in. Germination, budding, flowering and ripening began in different variants of the experiment almost simultaneously. Yet, certain differences in the growth of plants could be noticed. Against the non-salty background the plants from the seed treated with boric acid began with lagging behind the controls in growth. But later on they began growing quicker, and those which had been treated with 0.4 % boric acid came even ahead of the controls by July 11, while at the end of the experiment they were on the average 5 cm higher compared to the latter. Against the salty background the treated plants also lagged behind the controls, when they began vegetating, but soon they came up with them, and on June 21 the plants of the boron variants were ahead of, while at the end of the experiment they were 10—8 cm higher than the controls. The curves in Fig. 1 bring out the change in growth, as recorded in all the variants every ten days.

Aside from their height the experimental plants of both background variants differed from the controls in their being more vigorously developed in general (Figs. 1 and 2). At the end of the experiment there was counted the number of ripened balls and the yield (total dry mass, raw material and single organs). The results are summarized in the table. As is seen from the table, soaking of seed in boric acid increases (against both backgrounds) the total yield of dry matter and raw material. Against the non-salty background the maximum increase in raw yield, and matter in general,

Fig. 1. Rightwards: control, 0.4% boric acid, 0.7% boric acid. Non-salty background.

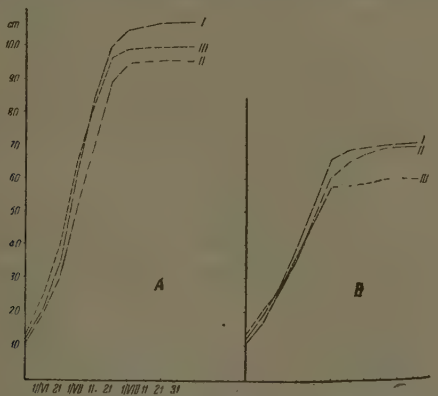
Fig. 2. Rightwards: control, 0.4% boric acid, 0.7% boric acid. Salty background.

was obtained with the seed soaked in 4% boric acid. That treated with 0.7% boric acid, to the contrary, gave this maximum against salty background. The relative increase in yeld due to treatment attained its maximum in plants grown in salty soil. All expetrimental plants against both backgrounds had a great number of balls. Enhanced fruiting due to boron has more than once been reported in literature ([2], [4], [5]).

As compared to controls, the experimental plants showed more vigorous development, better growth and fruiting, their yield was enhanced. We can therefore speak of the soaking of seed in boric acid as a means which goes to satisfy the boron requirement of cotton. We are not entitled to say, however, on the basis of the data obtained that it can be fully satisfied in that way.

Experimental variants	No of balls per plant	Weight per plant in grams					
		Total air dry mass	Raw material	Leaves	Stems	Valves	Roots
Non-salty background:							
Control	25.5	274.5	111.5	62.7	44.4	28.4	27.5
	100	100	100	100	100	100	100
0.4% boric acid	36.5	344.2	139.3	66.3	63.9	52.3	22.4
	143.2	125.4	124.9	105.7	143.9	184.2	83.4
0.7% boric acid	29.0	327.1	129.8	78.8	62.4	33.9	22.2
	113.7	119.1	116.5	125.7	140.6	120.1	80.7
Salty background:							
Control	8	72.1	36.0	16.2	8.6	7.2	4.1
	100	100	100	100	100	100	100
0.4% boric acid	10	104.4	38.5	25.9	22.1	11.8	6.1
	125	144.8	106.1	159.9	256.9	163.5	148.8
0.7% boric acid	16	119.3	52.9	30.2	14.7	15.2	6.3
	200	165.5	147.1	186.4	170.9	211.1	153.7

The data obtained against the salty background furnish definite evidence that the effect of the boron treatment of seed (soaking in boric acid before sowing) is to increase salt resistance in cotton. We are inclined to ascribe the increased salt resistance to the influence of the boron on the absorption of salts by the roots. It is namely the uptake of chlorine from the nutrient medium which goes down ([7], [8]). This circumstance is of special importance for cotton at the first period of development. When chlorine is introduced into the soil, we have also to expect a certain increase in salt resistance. But this increase



[Fig. 3. Growth curves. *I*—0.4% boric acid; *II*—0.7% boric acid; *III*—control; *A*—non-salty background; *B*—salty background.

may possibly prove to be lower than with boron treatment of seed, since the roots of the seedling, while striking in soil, will not always meet boron. And it is likely to happen that the required amount of boron will be absorbed considerably later than in the early periods of development.

The increase in the salt resistance and yield of cotton due to boron treatment of seed has been obtained with a concentration of boric acid varying within a rather wide range. This seems a good ground for the assumption that the boron treatment of seed as a means for increasing salt resistance and yield of cotton may easily be applied under industrial conditions. Its large scale introduction into industry must, however, be preceded by field experiments against both salty and non-salty backgrounds, since the conditions prevailing in field are sharply different from those of a vegetation experiment.

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TAXONOMY

ECOLOGICAL DIFFERENTIATION OF THE CHERRY PLUM *PRUNUS CERASIFERA* EHRH. (s. l. Kov.)

By N. V. KOVALEV

(Communicated by N. I. Vavilov, Member of the Academy, 25. III. 1939)

The cherry plum is a wild plum of Eurasia, widely distributed in the forests of Southern Europe, Anterior Asia and Soviet Middle Asia. It has been introduced into cultivation in north-western India, Syria, Iran, southern Anatolia and the Caucasus (especially on the Apsheron peninsula), where it prevails over the common plum, *Prunus domestica* L. (1). The fruits of the cherry plum contain somewhat less sugar that the common plum, i. e. 6—9% instead of 6—13%, up to 7% of citric acid to dry weight (according to the data of Levina of the Institute of Plant Industry), as much as 6—17 mg% of vitamin A' (according to the data of J. Murri of the Institute of Plant Industry), and up to 1.5% of pectines. At the same time, cherry plums contain no tannic substances. The Institute of Plant Industry has collected as many as 100 different varieties of cherry plums with large fruits suitable both for canning or for the table (dessert varieties from Iran).

The cherry plum plays an important rôle in the breeding of plums, especially in this country, where the problem is raised of synthesizing the cultivated plum by hybridization between the blackthorn and the cherry plum (2), and of creating new varieties of plums by crossing all of the 8-chromosome group of American (*P. americana* and others) and East-Asiatic (*P. salicina* and others) plums with cherry plums. As has been pointed out by N. I. Vavilov (7), this necessitates a more thorough study of the cherry plum and organizing a nursery for the initial material.

The main work has been carried out by Ekimov (4), who in 1928—29 collected nearly 1500 herbarium sheets and up to 1200 living specimens of cherry plums from different habitats in the Caucasus. Soviet Middle Asia has been investigated in this respect by Popov (5), Kostina and others (6,7). In the Crimea Ryabov is working on cultivated forms of cherry plums.

The writer has studied cherry plums both in their natural habitats in the Caucasus and Soviet Middle Asia and in the nurseries of the Maikop Experiment Station. He has, moreover, studied the herbaria of the Institute of Plant Industry and of the Botanical Institute of the Academy of Sciences and enriched the herbarium and the collection of living specimens with many new, chiefly cultivated forms. Owing to this, he succeeded in working out in more detail the taxonomy and ecology of cherry plums (in the broad sense) and to select valuable varieties for cultivation on a larger scale.

We became thoroughly convinced that Ledebour's description (8) of *Prunus divaricata* (1827) and Ehrhard's of *P. cerasifera* (1789) do not essentially differ and may be regarded as identical. Subsequently, a number of botanists [Boissier (8), Schneider (9), Koehne] referred to *P. divaricata*

forms with yellow fruits, while Medvedev ([10]) and Haussknecht referred to it those with red and purple-red fruits. Schneider ([9]) classified *P. divaricata* as a subspecies of *P. cerasifera*, while Bailey gave it only varietal rank (*P. cerasifera* var. *divaricata* Bailey), ascribing to this variety only yellow fruits. However, such a character as fruit colour is largely variable in many species of plums. It is well known, for instance, that such species of plums as *P. salicina* have green, yellow, red or reddish-violet fruits, while *P. americana* has yellow, red, or dark-purple fruits.

Nobody has determined separate areas for *P. cerasifera* and *P. divaricata*, which cannot be done, both species being identical. We could establish that *P. monticola* C. Koch, found by Koch in north-eastern Anatolia, does not differ at all from the cherry plum and may be discarded as a species. Similarly, *P. pseudoarmeniaca* Held. and Sart., found in Greece, is identical with *P. cocomilia* Ten. ([11]); this has been confirmed by Adriano ([12]). Upon examining *P. cocomilia* Ten., we found that this species is identical with *P. cerasifera* Ehrh. *P. cocomilia* Ten. may be retained only as a variety, based on the character of two flowers per bud, a character occasionally found by us in different forms of cherry plums and even of blackthorn (*P. spinosa* L.).

Having established a broader diagnosis of cherry plums, comprising new, formerly unknown forms, such as forms with pitted, compressed stones, forms with compressed stones having a broad, sharp keel and a truncate base, forms with velvety-pubescent stones, forms with leaf blades and peduncles having velvety or tomentose pubescence, etc., we were confronted with the task of classifying this extensive material. We studied, first of all, general ecological characters—drought resistance, duration of dormant period, time of flowering, age of bearing, general character of the tree's habit and growth. Further morphological characters were studied, particularly characters of the stone, fruit and leave. We investigated the whole vaste area of the cherry plum, embracing the Tian-Shan wooded steppe, the narrow ravines of the Kopet-Dag, the Lebanon mts., the Anti-Lebanon mts., the mountains of southern Anatolia (Anti-Taurus), the slopes of the Main Taurus range, the high mountains and open forests of eastern Anatolia (lake Van) and Armenia, the humid forests of northern Anatolia and Kolkhida, the moderately cold regions of the North Caucasus, and, lastly, the Talysh region with its peculiar climatic conditions (dry summer and humid fall). Differences in annual precipitation (from 200 to 2500 mm), temperature (the mean temperature for January ranging from +5° to —7—10°C) and soil variations have all had their effect on form-genesis, while the fact that the area is composed of regions separated form one another by mountain ranges has given rise to a number of ecotypes of cherry plums. In those cases where the isolation of ecotypes occurred comparatively long ago, the divergence has led to the formation of separate species. As the primary center we took Armenia, eastern Georgia, and the district of Talysh. The conditions in these regions are especially favourable for the genesis of forms; we seem to find here the greatest diversity of cherry plums, both as regards fruits and particularly the vegetative period (from June 2 to November 10).

1. Irano-Armenian Ecotype. This is the basic ecotype of the above center; its distinguishing characteristics are as follows. Low (3—5 m) tree or shrub, very thorny, highly drought resistant, comparatively late in flowering, dormant period stable, flowers small, fruits fairly large, red, yellow, or nearly black, stones very large, coarsely pitted or scabrous, plump. We have given this ecotype the rank of a subspecies and have named it *Prunus cerasifera* Ehrh. ssp. *nairica* Kov. ssp. n.

2. Mountainous Nakhichevan Ecotype. A special ecotype found in the regions adjacent to the preceding—in Ordubad-Migri

district under cultivation and in northern Iran in a wild state. Tree tall (8—10 m), thornless, leaves larger, fruits pinkish-green or light red, stones compressed with broad, sharp keel and truncate base, flesh of fruit very sweet and extremely juicy. This ecotype has also been given the rank of a subspecies, *P. cerasifera* Ehrh. ssp. *nachichevanica* Kov. It is widely cultivated not only in Transcaucasia, but also in Iran and in Soviet Middle Asia under the names «Kok-sultan» and «Kzyl-sultan». The stones in these forms have an even sharper keel.

3. Black Sea or Pontic Ecotype. This ecotype inhabits western Georgia and northern Anatolia, regions where the rainfall is comparatively uniform throughout the year and very abundant (1800—2500 mm a year). It is distinguished by its thin, dark green leaves, sparsely pubescent along the midrib, its being hydro- and thermophile, by its shorter dormant period, earlier flowering, greater fleshiness of fruits, and its small, smooth stone. The fruits are red, yellow or nearly black with red or yellow flesh. The tree is up to 10 m tall, slightly thorned, and the trunk attains a diameter from 30 to 60 cm. This Black Sea ecotype has been given by us the rank of a subspecies, *P. cerasifera* ssp. *pontica* Kov. et V. Ek. ssp. n.

4. North Caucasian Ecotype. This ecotype, which occupies the region in the North Caucasus from Tuapse—Maikop to Ordzhonikidze, is the most cold resistant type (withstands frosts as low as —35°C). It has comparatively large flowers, small, smooth stones, often with a ridge along the ventral suture, and a stable dormant period. It is characterized by luxuriant growth, attaining a height of 10—15 m and a trunk diameter of 30—80 cm. This ecotype has likewise been ranked by us as a subspecies *P. cerasifera* ssp. *borealicaucasica* Kov. et V. Ek.

5. Ghirkan Ecotype. This ecotype inhabits the regions along the shore of the Caspian Sea from Derbent—Kuba to Lenkoran, along the slopes of the Talysh mts. to northern Iran (Astrabad), and along the slopes of the Elbrouz mt. It differs markedly from the preceding forms of cherry plum in being xerophytic. The leaves of this type have a dense velvety or tomentose pubescence on their under surface, a character not reported for the genus *Prunus* s. str. The upper surface of the leaf blade is less densely pubescent. The petioles and peduncles are also pubescent. The stone is plump, usually smooth or slightly pitted. We have given this ecotype the rank of a separate species, *P. caspica* Kov. et V. Ek. sp. n.

6. Foveate Sub-Ecotype. On the Apsheron peninsula there is cultivated a special type of cherry plum with large, pale pink or white flowers, with sparsely tomentose, reddish-brown pubescence on the lower surface of the leaf blades, with compressed, somewhat corrugated stones, densely covered with fine pits (like a thimble), and with a deep ventral suture. We have classified this sub-ecotype as a subspecies of the preceding form, and because of its finely pitted stones we have named it *P. caspica* ssp. *foveata* Kov. et Streb.

7. Iran Ecotype. On the Apsheron peninsula and in Iran there has long been cultivated (also found in north-western Iran in a wild state) a special ecotype characterized by dense velvety pubescence of the leaves, bluish-grey bark on 2—3 year old shoots, and broad or oval-shaped stones with a velvety pubescence, the last-mentioned character not encountered in any other form of the genus *Prunus* s. str. This ecotype we have ranked as a species *P. iranica* Kov. sp. n.

8. Tian-Shan Ecotype. This ecotype, growing in the region of the Tian-Shan and Kópet-Dag mountain ranges, is a low, xerophytic shrub with a deeply penetrating root system, small, light-coloured, more deeply indented leaves, small flowers and fruits (yellow, black, red) and

a stable dormant period. We have ranked this ecotype as a subspecies, *P. cerasifera* ssp. *orientalis* (M. Pop. pro var.) Kov. Comb. nova, and its variant from the Kopet-Dag region, called by M. G. Popov *P. cerasifera* var. *turcomanica* M. Pop., as a Kopet-Dag ecotype.

9. Syrian ecotype. This ecotype, which is found in northern Syria and southern Anatolia (Anti-Taurus) and was ranked by Kotschy as a separate species, *P. ursina*, is a low tree (3—4 m), having coarse oval-rhomboid leaves with a whitish pubescence along the midrib of the upper surface and over the entire lower surface, velvety pubescent shoots, reddish-violet fruits, sometimes yellow, with velvety pubescent peduncles. We thought it correct to classify this ecotype as an independent species, *P. ursina* Kotschy.

10. 24-Chromosome Hybrid Ecotype. This triploid type ($2n=24$), a hybrid between the cherry plum and the blackthorn and widely distributed in a number of regions of the Caucasus, was discovered there by Dr. V. A. Rybin. This type differs from both the blackthorn and the cherry plum. It propagates by means of sprouts arising from the roots to an even greater extent than does the blackthorn. It is characterized by large flowers, profuse flowering, and pubescence of the young shoots. Plants of this type are almost completely sterile. As this ecotype is widely distributed in nature, we have, for practical convenience, classified it as a separate species, *P. Rybini* Kov. sp. n.

11. 32-Chromosome Hybrid Ecotype. In the woods of the Caucasus Dr. V. A. Rybin discovered a form intermediate between the cherry plum and the blackthorn and having 32 as its diploid chromosome number. This tree bears dark red fruits and is fully fertile. Our investigation of its progeny showed it to be hybrid: 12 investigated seedlings had somatic chromosome numbers ranging from 16 to 24. We have also given this ecotype the rank of species and have named it *P. media* Kov. sp. n.

We should also mention the unique forms of cherry plum found by Kostina and Linchevsky in the Tian-Shan mts., which were shown by these investigators to be hybrids between the cherry plum and the flowering almond (*P. cerasifera* Ehrh. × *Amygdalis ulmifolia* M. Pop.). These hybrids were named by M. G. Popov *Prunus silvestris* M. Pop. As an ecotype, this species is characterized by greater cold resistance than the cherry plum, and grows at high altitudes, reaching the line of fir forests, as high as 2500 m above sea level. Some forms of this species have fruits approaching those of the almond with a dry pericarp; other forms—those of the cherry plum with a fleshy pericarp and red coloured skin.

The description of the new species isolated by us will be given in my article «New species of Plums».

In conclusion the writer desires to express his thanks to N. I. Vavilov and Dr. E. N. Sinskaya for their kind suggestions, advice and assistance in this investigation.

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TAXONOMY

NEW SPECIES OF PLUMS

By N. V. KOVALEV

(Communicated by N. I. Vavilov, Member of the Academy, 25. II. 1939)

In the forests of the Balkan peninsula, the Caucasus, Anterior Asia, and Soviet Middle Asia there grows wild the west-european species of plum, *Prunus cerasifera* Ehrh. (=*Prunus divaricata* Ledeb.), the so-called cherry plum (1). This species has been studied in our practical work both in its natural habitats and in the nurseries of the Maikop Experiment Station, where we have a collection of specimens comprising many hundreds of forms. We have also thoroughly studied the herbarium specimens of cherry plums collected by the staff of the Institute of Plant Industry—cheifly by Ekimov (2)—and of other institutions, and numbering about 2000 sheets. All this has enabled us not only to form a detailed idea as to the forms comprised within this species and to trace its differentiation into ecotypes, but also to reveal forms sharply distinct from the basic type of cherry plum, *Prunus cerasifera* Ehrh., differing from this type in charactens never described for any form of the entire genus *Prunus* s. str.

1. Forms growing in regions that adjoin the western and southern shores of the Caspian Sea—from Derbent througn the Talysh region and along the North Iran shore of the Caspian, particularly widespread in the Talysh region—proved to have dense velvety or tomentose pubescence on the lower surface of their leaves and sparse, short, pilose pubescence on the upper surface. Leaves are narrow, obovate, cuspidate. Petioles and peduncles are also pubescent. Young shoots, however, are glabrous. Branches are thornless; flowers white and of medium size. Stones are coarsely or finely pitted; fruits range from black to yellow in colour, are round or oval in shape, and from 20 to 35 mm in diameter.

Inasmuch as in the genus *Prunus* s. str. such a character as velvety pubescence of leaves (3) and petioles has previously not been described, we consider it possible to give these forms the rank of a separate species, *Prunus caspica* Kov. et V. Ekim. sp. n. There are species with tomentose pubescence of the leaves in the genera *Cerasus* and *Amygdalus*.

Those forms of this new species which have stones broad, compressed, and finely pitted (like a thimble) and leaves even more densely pubescent on their lower surface than most of the forms of this species, we have classified as ssp. *foveata* Kov. et Streb. ssp. nov. Forms of this subspecies have been introduced into cultivation in Azerbaidjan and northern Iran. They have large fruits, 25—40 mm in diameter, with a low content of citric acid, tender flesh, and of dessert type. These forms merit extensive cultivation

in southern regions of the USSR. Both the species and the subspecies have 16 as their diploid chromosome number.

2. Among forms from north-eastern Iran there are some that also have markedly pubescent leaves, but their flowers are large white or pinkish, and their stones are velvety pubescent, broad compressed, and irregularly oval. Since in the genus *Prunus* s. str. the character of pubescent stones has previously not been described, this character being known only in the Texas almond (*Amygdalus texana* W. E. Wight=*Prunus texana* Dietr.), we have decided to give these forms the rank of a separate species, *Prunus iranica* Kov. sp. n.

Fig. 1. *Prunus caspica* Kov. et V. Ekim.

Fig. 2. *Prunus caspica*, flowering branch.

Varieties of this species are cultivated in Iran and Azerbaidjan. The fruits are globular, red or yellow and white, with extremely sweet and juicy flesh, and almost entirely devoid of citric acid. These varieties should be widely

Fig. 3. *Prunus caspica*, fruits.

cultivated, especially in southern and hot regions of the USSR, as they are much more heat resistant than varieties of the common plum, *Prunus domestica*. The diploid chromosome number of this new species is also 16.

3. In the North Caucasus, in localities where the cherry plum (*Prunus cerasifera* Ehrh.) and the blackthorn (*P. spinosa* L.) grow side by side, Dr. Rybin (4) found in great numbers natural hybrids between these two species. These hybrids have 24 as their somatic chromosome number and are almost completely sterile, this sterility being due to their triploidy. Dr. Rybin also obtained hexaploid ($2n=48$) hybrids between the blactkthorn and the cherry plum.

This made us study in more detail the cherry plum and the blackthorn, especially forms distinguished by intermediate characters (of leaves, flowers, fruits, etc.). One of such forms investigated cytologically by Dr. Rybin, was found to have in its somatic cells 32 chromosomes, as in the blackthorn. This form was completely fertile, and was considered by Dr.

Rybin to be a blackthorn. Twelve of this form grown from seed were investigated by us cytologically, and an interesting segregation as regards chromosome number was revealed. Some plants had 16 and others had 32 chromosomes, the chromosome numbers of their presumed parents. A number of other plants, however, had $2n=24—26$ and one plant had $2n=18$. Hence, this form must be regarded as a hybrid. It differs from the cherry plum in having smaller flowers (18 mm), leaves are coarsely, sparsely and tomentosely pubescent on their lower surface (as in the blackthorn), blackthorn-like

Fig. 4. *Prunus media* Kov., branches with fruits.

stones, dark purple fruits, and shoots with short, coarse pubescence. It differs from the blackthorn in having longer and thinner peduncles, acuminate leaves with a glossy upper surface, and dark purple fruits with sour-sweet, non-astringent flesh of the cherry plum type, containing a considerable amount of citric acid. In view of the fact that forms of this type are commonly found in a wild state, have their own area of distribution and constitute the basis of the formation in nature of a new species, we consider it possible to give them species rank under the name *Prunus media* Kov. sp. n.

Hence, the genus *Prunus* s. str. [3] should be supplemented by the following species: 1) *Prunus caspica* Kov. et V. Ekim. sp. n., 2) *Prunus iranica* Kov. sp. n., 3) *Prunus media* Kov. sp. n., and by one subspecies: *Prunus caspica* Kov. et V. Ekim. ssp. *foveata* Kov. et Streb. ssp. n.

Two of these new species deserve being introduced at once into wide cultivation.

Furthermore, as a result of our investigation, it is clear that, in addition to species-formation by means of isolation (in the Darwinian sense) under special ecological conditions, there is also taking place an extensive process of creation of new forms (species) of fruit trees by means of hybridization.

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ENTOMOLOGY

GEOGRAPHIC VARIATION OF WHEATS IN THEIR RESISTANCE TO HESSIAN FLY (*PHYTOPHAGA DESTRUCTOR* SAY)

By P. G. CHESNOKOV

(Communicated by N. I. Vavilov, Member of the Academy, 11. III. 1939)

Serious damage caused by the Hessian fly through its attacking cultivated wheats and the lack of practicable measures directly to counteract the activity of this injurious insect have made it necessary to look for such varieties that would be unliable or but slightly liable to its attacks. In USA the work along this line has been in progress since the eighties of the last century (Packard, McColloch, Painter, Parker and oth.). But in pre-revolutionary Russia no attention whatever was paid to the question of the resistance of wheats to Hessian fly in the face of grave losses frequently entailed to the farming industry by this insect. It is only with the establishment of Soviet Power that the work on the subject has begun in this country, growing in importance from year to year.

At present our knowledge extends over a number of varieties which are free from or only slightly susceptible to the attacks of Hessian fly. The accumulation of data on the differences in the susceptibility of different forms gave rise to attempts of classifying the wheats according to this character. The classification adopted by most of the investigators consists in dividing the wheat species into either not or slightly susceptible (*Tr. monococcum*, *Tr. durum*) and strongly susceptible ones (*Tr. vulgare*, *Tr. compactum*).

In view of the fact, however, that slightly susceptible forms have of late been detected within the species *Tr. vulgare*, the correctness of such a classification becomes objectionable. The first to call it in question has been a soviet worker Klokov(1).

We have to point out here that the principle underlying the above division is to compare the liability of different forms to their being infected by the larvae and cocoons of the insect, while their behaviour in response to infestation is not taken into account.

A three year study of world's wheat assortment in its response to the attacks of Hessian fly, carried on in a region where the latter is of high economic importance (North Caucasus, Kuban), has led us to a conclusion that decisions in appraising the degree of resistance which different forms can offer to the fly must be based upon two indices: 1) their infestation by larvae and cocoons (estimated in terms of the ratio of plants and stems injured and the density of parasitic population); 2) their resistance to the injury (expressed in terms of the ratio of the plants survived to the total of plants infested and their productiveness).

With such methods of classification applied, a more elaborate differentiation of the forms tested with regard to their susceptibility becomes possible, and there is no danger for the forms equally infested but differently responding to the infestation to be united into one group.

In treating the material supplied by the experiment, we availed ourselves of the data on agro-ecological classification of wheats, which work is being done under the guidance and with direct assistance of N. I. Vavilov.

400 forms of spring wheat have been tested in field under such conditions as made their infestation with the insect highly probable and the results have been verified by artificially infecting 250 forms in cages. The date obtained enable us to trace some regularities in the geographical distribution of forms with reference to their infestation by the larvae and cocoons and resistance to the injury thus occasioned.

What may be inferred from these data is summarized in the following principal statements.

1. The division of wheat species into insusceptible and strongly susceptible ones needs qualification. Such a characteristic will not fit, unless the species concerned spreads over a small area. The forms of the species *Tr. monococcum* and *Tr. Timopheevi* are slightly susceptible. *Tr. persicum* and *Tr. sphaerococcum* include forms of medium and strong susceptibility respectively. Most of the forms within *Tr. dicoccum* are strongly susceptible, but slightly susceptible forms occur too. The widest range of susceptibility has been observed in *Tr. durum* and *Tr. vulgare*. This is distinctly shown by the data in the table.

Distribution of Principal Wheat Species and Fluctuations in Susceptibility of Different Forms

Species	Distribution	Number of forms tested	% of plants injured			Number of cocoons per 100 plants		
			Average	Range		Average	Range	
				from	to		from	to
Tr. monococcum	Caucasus, Balkan Peninsula, Mountain regions of Jugo-Slavia, Mountain regions of Germany, Spain, Morocco . .	13	6	0	22	14	0	61
Tr. Timopheevi	Western Georgia	4	16	2	23	14	0	26
Tr. persicum	Armenia, Georgia, Mountain Daghestan	6	48	42	60	186	140	220
Tr. dicoccum	Abyssinia, Morocco, Arabia, India, Transcaucasia, Volga provinces, North America	16	68	18	96	401	17	929
Tr. sphaerococcum	India, Punjab	4	70	55	75	322	261	384
Tr. durum	Mediterranean countries of Europe and Africa, Asia Minor, Steppe zone of the USSR, Middle Asia, Abyssinia, North America, Argentina, Australia	71	27	0	96	48	0	259
Tr. vulgare	Throughout the Old and New World where wheat is cultivated	230	41	0	100	145	0	572

2. Some regularities may be noted on comparing the susceptibility of different forms within one species. Most of the slightly susceptible forms of *Tr. vulgare* belong to the Mediterranean and Spanish groups as well as hybrids from Argentina (when Mediterranean forms were involved in crossing). The most strongly susceptible forms are found among the wheats from Armenia and Turkey (xerophilous group), Syria and Palestina, Egypt, Pamir an Badakhshan, Middle Asia (the latter group includes forms of medium susceptibility).

A great majority of Indian wheats are strongly susceptible, but under field conditions there are occasionally encountered forms of low and medium susceptibility. Wheats from the steppe zone of the USSR and those from

Fig. 1. Susceptibility and resistance of wheats as determined by their origin. Denotation: *1* — slightly susceptible, resistant, *2* — slightly susceptible, non resistant, *3* — medium susceptible, resistant, *4* — medium susceptible, non resistant, *5* — strongly susceptible, resistant, *6*—strongly susceptible, non resistant.

Canada and USA (Canadian hybrid group) display a wide range of variation, as regards the susceptibility of separate forms, though medium susceptible forms predominate among them. The wheats from Eastern Siberia showed a medium susceptibility when growing in field (against a provocative background) and a strong one when artificially infected in cages. Manchurian wheats proved to be strongly susceptible.

Most striking differences in susceptibility are observed among hybrid groups, especially that of Argentina.

Within *Tr. durum* slightly susceptible forms are represented by the Mediterranean (incl. inland Spain) and Steppe groups; strongly susceptible, by the Abyssinian group (where they approach to strongly susceptible forms of *Tr. vulgare*); the intermediate place belongs to part of Syrian wheats (Khoranki).

3. The differentiation of forms becomes more elaborate, if their resistance to the injury is considered. We find this character to be definitely related to the origin and ecological group of the form concerned (Fig. 1).

This is especially conspicuous in the case of aboriginal varieties from a definite ecological region and in part applies to varieties produced by selection, whereby their adaptation to the specific conditions of the region had been taken into account. Not a single form resistant to the injury could, for instance, be detected among strongly affectible forms of *Tr. vulgare*, which refer to the Armenian-Turkish, Syrian-Palestinian, Egyptian, Middle Asiatic, Pamir-Badakhshanian, Indian and Chinese-Japanese groups. On the other hand, the resistance to the injury of some strongly affectible forms has been stated in the Steppe, Forest-steppe, East-Siberian groups, Canadian hybrids and the wheats from Manchuria. Within *Tr. compactum* all the strongly affectible forms of Armenian, Anatolian and Iranian groups

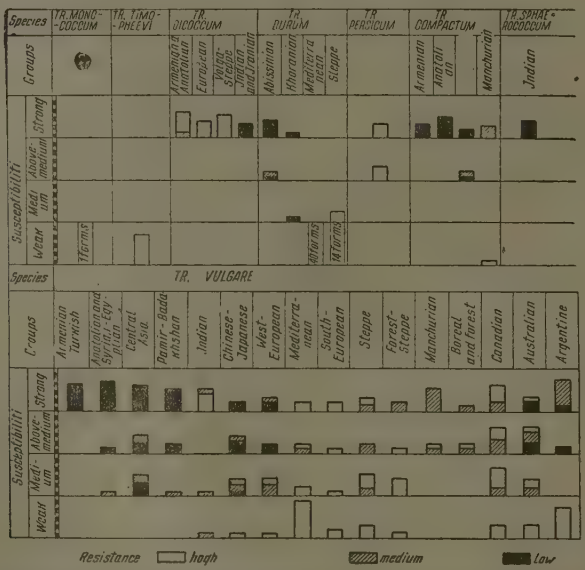

Fig. 2. Response of species and agro-ecological groups of wheat to Hessian fly.

respond with their dying away to the injury, while the same degree of affection is not lethal for the forms from Manchuria. Indian forms of *Tr. sphaerococcum* prove to be not resistant and so are also the forms of *Tr. vulgare* from the same region.

The forms of *Tr. persicum* are distinguished by their resistance even to a strong injury. Within *Tr. dicoccum* most of the forms are resistant (from Armenia, Syria, Volga provinces, and partly Eastern Europe); the exception is with the forms from Abyssinia, India and Iran. Among *Tr. durum* the forms from Abyssinia and partly Syria (Khoranki) have proved to be not resistant.

These relations are brought out in Fig. 2.

4. From comparing the infestation of some wheat forms by the northern (Pushkin, Leningrad province) and the southern (Kuban) population of the fly, we have established that the former differs from the latter in its activity against fodder plants. The flies of the northern population did not fail to infest those varieties which remained indifferent to the attacks of flies from the southern population (variety Illini Chief and oth.). This points to their having a wider range of adaptability with respect to the host in question.

5. The evidence furnished by studying the infestation in a great variety of forms with reference to their peculiar anatomico-morphological characters (which are considered as factors in affectibility by some of the investigators) is that a single character can by no means account for the plant being unliable to infestation. Thus, Mc. Colloch and Salmon's (2) attitude toward the height of the ligulae and its close contact with the stem as a factor determining the infestation is inconsistent with the fact that the wheats from Cyprus destitute of ligulae have been found by us insusceptible. The same is true of pubescent leaves which are believed to be responsible for the liability of the plant to infestation. This opinion is refuted by the strong susceptibility of some forms in *Tr. vulgare*, which are bearing no pubescent leaves; the rôle of a compact structure of stem has already been questioned in the works of Anderson and Brown (3).

Somewhat more truth seems to lie in the attempts to interprete the insusceptibility of plant forms in terms of their biochemical peculiarities, however, this interpretation is not free from objection either, as shown by the data (Haseman, Klokov) on the contents of ash (calcium, silicon).

We are compelled therefore to give up the attempts of explaining the inaffectibility of wheat forms by the rôle of some characters acting separately. It is a complex of factors which determines the inaffectibility of forms and their resistance to injury, and their anatomico-morphological characters can be of importance only in co-operation with other elements of the complex (rate of growth and development, biochemical peculiarities).

6. Further progress in the study of the behaviour of a great variety of wheat forms in response to the attacks of Hessian fly, whereby the attention should center about the rôle of the complex of specific character, will supply us data for an adequate explanation of causes responsible for the inaffectibility of forms and their resistance to injury.

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ANIMAL MORPHOLOGY

DEVELOPMENT OF CUTANEOUS SENSORY ORGANS OF THE LATERAL SYSTEM IN *ACIPENSER STELLATUS*

By N. DISLER

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There are fragmentary literary data on the development of the cutaneous sensory organs of the lateral system in *Chondrostei* ([4], [2], [3]).

My observatons have shown that primary rudiments of the cutaneous channels and follicles in sturgeon appear on the 7th day following fertilization when the embryo is 8 mm long*. The primary rudiments of the cutaneous channels and follicles are well visible upon fixation with corrosive sublimate. When embryos are examined in falling light, the rudiments appear to be decidedly lighter than the surrounding ectoderm.

In an embryo 8 mm long the rudiments of the supra-orbital and infra-orbital channels are situated behind and somewhat above the eye, in front and somewhat beneath the rudiment of the auditive vesicle. These rudiments are connected with the ganglion of n. VII, which is situated immediately in front and below the auditive vesicle.

Immediately behind the auditive vesicle are situated the rudiments of the lateral channel and of the accessory follicles. Right ahead of the rudiment of the accessory row of follicles is the rudiment of the supra-temporal channel. From the dorsal end of it later differentiates the posterior one of the two dorsal follicles of the head. All the enumerated rudiments are connected with the ganglion of n. X which is below and to the rear from the auditive vesicle.

In front of the rudiment of the supra-temporal channel is the rudiment of the anterior one of the two dorsal follicles of the head. The lower end of the rudiment of that follicle is connected with the thickening of the ectoderm which is located at the level of the lower edge of the auditive vesicle. The upper one lies in the ectoderm covering the middle portion of the auditive vesicle. The ganglion of n. IX, to which this rudiment is connected, is scarcely discernible when the embryo is studied in falling light, but may be traced on slides.

In an embryo 8 mm long the rudiments of the dorsal row of follicles, those of the gular row of follicles, of the hyomandibular and ventral follicle are not yet discernible. The rudiments of these organs appear in the embryo 10—11 mm long.

The cutaneous channels and follicles develop in sturgeon as a result of growth of primary rudiments. The rudiment of the supra-orbital channel

* The development of the embryos was detained by exposing eggs (at the stage of closing of the blastopore) to a temperature of 13—17° C during their transformation, the latter lasting a little over 24 hours; all the remaining time the development proceeded at a temperature of 22—25° C.

develops above the eye. Its growth is obstructed and stopped in front of the eye by the rudiment of the olfactory organ. The growth of this channel and its nerve above the olfactory orifice occurs only on the 11th or 12th day following fertilization in an embryo 15—16 mm long.

In *Plagiostomi* (*Squalus*, *Spinax*), following Mitrofanov (4), Johnson (5) and Rund (6) there occurs no such impediment in development of the primary rudiment of the supra-orbital channel. The rudiment of this channel in *Plagiostomi* during its growth bends round the olfactory orifice from its lateral side. The more vigourous development in *Plagiostomi*, as compared with *Chondrostei*, of the whole system of cutaneous sensory organs, which are innervated by r. ophtalmicus superficialis n. VII, should evidently be explained by the absence of impediment of development of the primary rudiment of the supra-orbital channel and of the nerve connected with it.

The development of the supra-orbital channel and its relation to the olfactory orifice in sturgeon is similar to that in bony ganoids *(Amia)*, which may be deduced from drawings supplementing the work by Allis (1).

The path of growth of the rudiment of the infra-orbital channel of sturgeon lies beyond the eye and is directed down and forward. On the lower surface of the head the rudiment of this channel bends round outside of the rudiment of the barbs, and, having attained the anterior end of the rudiment of rostrum, unites with the corresponding channel of the opposite side of the head.

In *Plagiostomi (Pristiophorus*, *Pliotrema)*, possessing barbs on the lower surface of the rostrum, the infra-orbital channel is situated inwardly from them. The position and the path of growth of the rudiment of the lateral channel in sturgeon are similar to those in *Plagiostomi* as shown by Johnson (5) in *Squalus*. They differ in bony ganoids *(Amia)* in the following way: while in *Plagiostomi* the rudiment of the lateral channel develops into the upper lobe of the tail, in *Amia* (after Allis) the rudiment of the channel grows over the rudiment of the definitive tail, which develops lower and behind the upper lobe of the tail of the embryo.

The rudiment of the accessory follicles of sturgeon develops to the rear following the growth of the rudiment of the lateral channel adjoining it from the dorsal side. Individual follicles are differentiated on the path of its growth. Following Allis, the process of formation of accessory follicles in *Amia* is very much similar to that found in sturgeon. Observations of Johnson (5) demonstrate that accessory follicles are formed in *Plagiostomi (Squalus)* in contrast to *Chondrostei* and *Holostei* as a result of budding of the same organs of the lateral channel.

The dorsal follicles in sturgeon are formed from a rudiment which grows to the rear along the dorsal surface of the body in the region between the lateral channel and the dorsal fin fold. The formation of these follicles is similar in *Chondrostei*, *Holostei* and *Plagiostomi*. The rudiment of the supra-temporal channel of sturgeon grows up behind the auditive vesicle. Ahead of it is differentiated the posterior one of the two dorsal follicles of the head.

The development of this channel and the way of its separation from the rudiment of the dorsal follicle is very much similar in sturgeon to the development of the corresponding channel in *Amia* (with the only difference that a row of follicles are developed in *Amia*, instead of a single one). In *Plagiostomi* the development of the two dorsal follicles of the head is not connected with the development of the supra-temporal channel, in spite of the fact that the two structures are innervated by n. vagus. *Plagiostomi* differ in this respect both from *Chondrostei* and from *Holostei*. Ahead of the rudiment of the supra-temporal channel on the surface

of the auditive vesicle in sturgeon is located the rudiment of the anterior dorsal follicle of the head. This rudiment is connected with the ganglion of the n. of the IX pair.

The primary rudiment of the gular row of follicles appears in sturgeon on the lateral surface of the gill covers of the embryo and, during development, changes its position but slightly, being differentiated at the place of its origin into individual follicles. The position of this rudiment in sturgeon is similar to that of the corresponding rudiments in *Holostei* and *Plagiostomi*, as may be seen from the works by Allis ([1]), Rund ([6]) and Johnson ([5]).

The primary rudiment of the ventral follicle appears on the ventral surface of the gill cover of the embryo of sturgeon. The position and innervation (n. of the IX pair) of this rudiment are similar to those of the rudiment of the row of ventral follicles in *Amia*, as noted by Allis ([1]). In *Plagiostomi* the rudiments of the ventral follicles belonging to the first gill arch are absent.

The number of individual sensory organs in sturgeon, which are formed on the head from the primary rudiments, remains unchanged after having been determined toward the 10th day following fertilization (the length of the embryo equals 14 mm). The number of individual cutaneous sensory organs on the body is determined later. Early setting of the individual cutaneous organs, the number of which remains further unchanged, is also characteristic of the development of *Plagiostomi* and *Holostei*.

Closing of the cutaneous channels in sturgeon begins in the region of the anterior part of the lateral channel in the 14—15 day old embryo which is 16—19 mm long. The process of closing of the channels is not yet fully completed in one-month old young 42—46 mm long; it is intimately connected with the development of integumental ossification which constitutes the bony skeleton of the cutaneous channels, as shown by the works of Sewertzov ([2], [3]).

The rudiments of the cutaneous sacks appear in an embryo 11—12 mm long. In sturgeon initially appear the rudiments innervated by r. mandibularis externus n. VII.

In *Plagiostomi* the hyomandibular group of Lorenzini ampullae appear first. Then appear the rudiments of the cutaneous sacks innervated by r. ophtalmicus superficialis and r. buccalis n. VII. Rudiments of the cutaneous sacks at early stages have in sturgeon the appearance of rounded depressions which assume in the course of development the shape of compound rosettes. Individual parts of these rosettes differentiate further, giving rise to groups of organs. This complex process of differentiation is not yet completed in one-month old embryos of sturgeon (42—46 mm long).

Conclusion

The study of the development of the cutaneous organs of the lateral system of sturgeon supports the conclusions reached on the basis of the study of an adult sturgeon structure, thus demonstrating one additional similarity between *Chondrostei* and *Holostei*. The accessory organs in both proved to develop from an autonomous rudiment, whereas in *Plagiostomi* they develop through budding of the organs of the lateral channel.

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ANIMAL MORPHOLOGY

STRUCTURE AND INNERVATION OF THE CUTANEOUS SENSORY ORGANS OF THE LATERAL SYSTEM IN *ACIPENSER STELLATUS*

By N. DISLER

(Communicated by I. I. Schmalhausen, Member of the Academy, 12. III. 1939)

Works devoted to the study of individual parts of the cutaneous sensory organs of the lateral system prevail in the literature. They give no full idea of distribution and structure of these organs in *Chondrostei*. However, just a full study is of great interest owing to the great biological importance of these organs and to the fact that it would bring great clarity into the question on the position of the cartilaginous ganoids in the system of fishes. It should furnish data for the solution of the problem as to whether the structural peculiarities of these fishes are the result of their primitivity or, on the contraty, that of their degeneration.

The following structures belong to the cutaneous sensory organs of the lateral system in sturgeon: cutaneous channels, cutaneous follicles («pit-organs»—Allis, «cup-like organs»—Norris) and cutaneous sacks («nerve sacks»—Allis, Norris, «sensitive pits» of Zograf).

Cutaneous channels and cutaneous follicles are present in *Plagiostomi*, *Chondrostei* and *Holostei*. Cutaneous sacks are absent in *Holostei*. They are typical only of *Chondrostei*. In *Plagiostomi* there are organs homologous to the cutaneous sacks of *Chondrostei*, viz., the Lorenzini ampullae. It should be noted that Lorenzini ampullae were found among *Teleostei* in certain *Siluridae* ([5]).

A structural peculiarity of the cutaneous organs of the lateral system in sturgeon and in all *Chondrostei* ([2,6]) consists in a weak development on the head of these fishes of organs innervated by r. ophtalmicus superficialis n. VII, as compared with those innervated by r. buccalis n. VII; in connexion with this r. buccalis is much more vigorously developed in these fishes than r. ophtalmicus superficialis. They differ in this respect from both *Plagiostomi* and *Holostei*, in which the organs of the two groups are developed about in the equal degree.

Four cutaneous channels are distinguished in sturgeon.

1. The supra-orbital channel in sturgeon with respect to the position of its anterior end between the olfactory orifices located on each side of the head is very much similar to that in *Holostei* ([1]) and in the majority of *Teleostei* ([2]); it differs in position from that in *Plagiostomi*, where it bends around the olfactory orifice from the outside. This channel is innervated by r. ophtalmicus superficialis n. VII.

2. The infra-orbital channel is situated on the lower surface of the rostrum outwardly from the barbs; sturgeon differs in this respect from *Plagiostomi* [*Pristiophorus*([4]), *Pliotrema*([3])] when it is localized inwardly from the barbs.

This channel is innervated in sturgeon by r. buccalis n. VII, except for its dorsal portion which lies in front of the supra-temporal channel. In this region the infra-orbital channel of sturgeon is innervated by n. glossopharyngeus, in its posterior portion, and by r. oticus n. VII, in the anterior one. In *Holostei*, according to Allis (1) and Norris(6) innervation of the infra-orbital channel is similar to that in sturgeon. In the majority of *Plagiostomi*, in contrast to *Chondrostei* and *Holostei*, the whole of the infra-orbital channel is innervated by r. buccalis n. VII. The exception is *Chlamydoselachus* where its innervation is similar to that in *Chondrostei* and *Holostei*.

3. The supra-temporal channel in respect to position and innervation by a branch of r. lateralis n. X is similar to that in the majority of *Chondrostei*, *Plagiostomi* and *Holostei*.

4. The lateral channel is situated laterally and is similar in this respect with that in *Chondrostei*, *Holostei* and in the majority of *Plagiostomi*. The lateral channel is innervated in sturgeon along its whole length by r. lateralis n. X; the similar innervation of this channel we find in *Holostei* (1, 6). In contrast to *Chondrostei* and *Holostei* the lateral channel of *Plagiostomi* in its portion located immediately behind the supra-temporal channel is innervated by a branch of n. glossopharyngeus. The exception is *Chlamydoselachus*, where, like in *Chondrostei* and *Holostei*, the whole lateral channel is innervated by n. vagus. In all other respects the innervation of this channel is similar in *Plagiostomi*, *Chondrostei* and *Holostei*.

The following cutaneous follicles are distinguished in sturgeon. On the lateral surface of the gill cover is located the gular row which consists of 5 follicles. Outside of this row and somewhat forwards of it lies one hyomandibular follicle. These follicles are innervated by r. mandib. externus n. VII.

In *Polyodon* (6), at the place where the gular and the hyomandibular follicles are located in sturgeon, lies a long cutaneous channel; its structure shows that the rudimentary character inherent in the cutaneous organs of this region of the head in sturgeon is not typical of all the *Chondrostei*. In *Plagiostomi* the gular row of follicles is considerably more developed than in sturgeon. In *Holostei* (1, 6) at the corresponding place lies the operculo-mandibular channel. The hyomandibular follicle of sturgeon in respect to its position corresponds to the hyomandibular channel in *Plagiostomi*, whereas in *Holostei (Amia, Lepidosteus)* a row of follicles is located at the corresponding place. One ventral follicle of sturgeon, situated on the ventral surface of the gill cover is innervated by a branch of n. glossopharyngeus which passes over the first gill arch. In other *Chondrostei (Polyodon, Scaphirrhyncus)*, according to Norris (6), no organs homologous to this ventral follicle were found in sturgeon. A number of organs described by Norris (1925) in *Amia* and *Lepidosteus* are of great interest, they are innervated by a branch of n. glossopharyngeus which passes over the first gill arch. These organs in respect to their position are homologous to the solitary ventral follicle in sturgeon.

In *Plagiostomi* there are no follicles homologous to ventral follicles of *Chondrostei*. The ventral follicles of *Plagiostomi* belong to other branchiomeres than the organs of the sturgeon and *Holostei*. In *Squalus* the ventral follicles are innervated by a branch of n. vagus passing over the fourth gill arch, whereas in *Heptanchus* it passes over the sixth one. The two dorsal follicles of sturgeon situated in front of the supra-temporal channel are innervated: the anterior one by a branch of n. glossopharyngeus, the posterior one—by a branch of n. vagus.

In *Amia* (1) two rows of follicles are situated at the place which corresponds to the anterior and posterior folllicles in sturgeon; the anterior one is innervated by n. glossopharyngeus, the posterior one—by n. vagus.

In *Chlamydoselachus* (*Plagiostomi*) these organs are innervated similarly to those of *Amia*. In the majority of *Plagiostomi* (*Squalus*, *Heptanchus* and others) the two dorsal follicles are innervated by n. vagus; in this respect the above group differs from *Chondrostei* and *Holostei*.

Two rows of cutaneous follicles, the dorsal and accessory ones, are located on the body of sturgeon; they are innervated by n. vagus. These rows of follicles of sturgeon are similar in position and innervation to the corresponding rows of follicles in *Holostei* and certain *Plagiostomi*.

The following groups of cutaneous sacks are distinguished in sturgeon. Two groups of supra-orbital sacks are innervated by r. ophtalmicus superficialis n. VII. The position of these groups of cutaneous sacks of sturgeon relatively to the supra-orbital channel and to the eye is similar to the position of the dorsal groups of the Lorenzini ampullae in *Chlamydoselachus*. Two groups of the supra-temporal cutaneous sacks are innervated by r. oticus n. VII. In *Plagiostomi* there are no groups of Lorenzini ampullae corresponding to the groups of cutaneous sacks in sturgeon.

The hyomandibular group of the cutaneous sacks is innervated by r. mandibularis externus n. VII. It corresponds in position and innervation to the hyomandibular group of the Lorenzini ampullae in *Chlamydoselachus*, *Squalus* and *Heptanchus*.

The cutaneous sacks of sturgeon innervated by r. buccalis n. VII constitute four groups: two infra-rostral ones, one infra-orbital and one supra-rostral. The two infra-rostral and the infra-orbital groups of the cutaneous sacks in respect to innervation as well as to position relatively to the mouth, infra-orbital channel and eye may be compared to the groups of Lorenzini ampullae in *Plagiostomi* (*Squalus*, *Heptanchus*). The upper rostral (supra-rostral) group is innervated by r. buccalis and is inherent only in *Chondrostei*.

The results of the study of innervation of the cutaneous organs of the lateral system of sturgeon enable one to the following conclusions:

1. The features of reduction are slightly expressed in the structure of the cutaneous sensory organs and are not inherent in the order *Chondrostei* as a whole. Thus, reduction noticeable in the cutaneous organs of the gill cover of sturgeon is absent in *Polyodon*.

2. *Chondrostei* possess the most primitive structural features of the cutaneous organs among all the *Teleostomi*. The presence of cutaneous sacks, the homologues of the Lorenzini ampullae of *Plagiostomi*, should be considered such a primitive character. In *Teleostei* (*Siluridae*) the Lorenzini ampullae occur in a considerably more modified form.

3. *Chondrostei* and *Holostei* possess certain common features of the structure of the cutaneous organs, which distinguish them from *Plagiostomi*, viz.: a) proliferation of the anterior end of the supra-orbital channel between the olfactory orifices on the two sides of the head; b) presence of the ventral follicles innervated by a branch of the IX nerve.

These structural peculiarities of *Chondrostei* and *Holostei* point to their common origin. The difference of the above characters of *Chondrostei* and *Holostei* from those of *Plagiostomi* justifies the suggestion that forms, from which they have originated, were different from *Plagiostomi* in structure of the cutaneous sensory organs.

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DEVELOPMENT MECHANICS

CONCERNING INDUCTIVE CAPACITY OF MEDULLA OBLONGATA IN EMBRYOS OF AMPHIBIANS

By G. P. GORBUNOVA

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Data existing in literature point to medulla oblongata as being the inductor of the ear vesicle; however, there is no unity of opinion on this question. On the basis of their experimental studies on amphibians, Harrison (1), Albaum and Nestler (2), Guareschi (3), Schmidt (4), Stone (5) have found that medulla oblongata is the inductor of the ear vesicle. Dalcq (6) considers that the primary «inductive center» of the labyrinth in *Discoglossus* is located in the region of the grey crescent. On ground of his experiments with the chick embryo, Szepsenwol (7) believes ganglion facialis and not the rudiment of medulla oblongata to be the «inductive center» of the labyrinth.

The present communication contains data which confirm the presence of the inductive properties of medulla oblongata and deals with variation of these properties with the age of the inductor. As material served the embryos of *Triton taeniatus*, *Amblystoma mexicanum*, *Rana arvalis*, *Rana esculenta* and *Bombinator igneus*.

The experiment consisted in transplanting a part of medulla oblongata rudiment under the ectoderm on the right side of another embryo. As donors served embryos at stages from 15 to 29 (according to Harrison). In all the experiments the hosts corresponded to stage 20. The larvae were usually fixed 3 to 6 days after operation. The experiments were conducted at a temperature 18—20°C. For treatment, the whole material was divided according to the age of the donor. Into the first group were included the operations with donors at stages 13—14; into the second one—those with donors at stages 15—17; into the third—the operations with donors at stages 18—21; into the fourth—the operations with donors at stages 22—29.

As a result of treatment of the experimental material, two regularly recurring phenomena were revealed, which have a great importance for all the series and dictate a definite classification of the data obtained. In the first place, it was found that the induction of the labyrinth in embryos at the stage of late neurula is possible only within a limited region. Secondly, that the action of the transplant may be expressed not only in the induction of an additional labyrinth, but also in the changes in shape and dimensions in the adjacent labyrinth of the host.

We did not aim at investigating the regional properties of the ectoderm in relation to a possible labyrinth formation. The results of our research permit only to point out that in the case a transplant happens to get under the ectoderm in the pronephros region, into the region of the gills or of the heart, no induction takes place. Therefore all the cases, where at the moment of fixation the transplant is in the regions enumerated above, are referred to the group of «unsuccessful» operations. On the other hand, in most of the

cases, if the transplant got near the area of the host labyrinth anlage, there is observed an increase of the size of the latter and changes in its shape, this phenomenon having a regular character. We were unable to establish the time of the deformation of the labyrinth. It is probable that the ear placode of the host coincides, either entirely or partly, with the induced one. It is even possible that under the joint action of the normal medulla oblongata and that of the transplant, the labyrinth anlage occupies from the very beginning a larger part of the ectoderm. This assumption is confirmed by a case from the series of operations on *T. taeniatus*, where medulla oblongata was partly disintegrated. In connexion herewith on the control side of the head at the moment of fixation, the labyrinth represented an invagination of the ectoderm, as yet not separated, while on the side where the transplant was located, there was formed a labyrinth of increased size. The enlarged ear vesicle of the right side might have been formed as a result of the simultaneous action of the transplant and of the host's medulla oblongata upon the labyrinth rudiment. In all cases, the deformation of the host labyrinth under the action of the transplant is distinguished by characteristic peculiarities: the labyrinth is chiefly enlarged at the expense of its elongation in the cranio-caudal direction; in most of the cases, the labyrinth is subdivided in the caudal part into two vesicles; there is no formation of semicircular ducts; the neuro-epithelial areas are diminished. Such cases of deformation of the labyrinth are also regarded by us as the manifestation of the transplant's inducing properties and they have been included in the total number of inductions. Let us consider the material of different series.

a) Transplantation of the Rudiment of Medulla Oblongata in Embryos of *T. taeniatus*. In all were studied 88 operated embryos. In 41 of them the induction of the ear vesicle was well expressed. Table 1 shows the distribution of the material and the frequency of induction according to age groups.

Table 1

Stage of donor	Number of «successfull» operations	Number of cases of induction	% of induction	Formation of additional ear vesicles	Only enlargement of the right labyrinth
13—14	3	2	67	2	—
15—17	13	13	100	9	4
18—21	36	21	58	19	2
22—29	16	5	31	3	2

Into this table are not included cases of «unsuccessful» operations, mentioned above. In the two first groups, the induced labyrinths are at an earlier stage of development than the labyrinths of the host. Their walls are made up of cubic epithelium. In dimensions they are behind the control labyrinths. In the third group the induced ear vesicles differ little in size from the normal ones. Differentiation of the epithelium is present, but the neuro-epithelium occupies a considerably smaller area than in the normal ear vesicles. The semi-circular ducts are not originated. In the last group the induced ear vesicles are much larger than the normal labyrinths (the stages of fixation are the same, as in the preceding groups), and in general configuration they show a resemblance with the latter. Their walls consist of flat epithelium. No signs of differentiation have been recorded.

The second group, where the donors were at the stage of a wide medullary plate with formed folds, has the greatest per cent of induction.

b) Transplantation of a Rudiment of Medulla Oblongata in Embryos of *Rana esculenta*. As donors in this series were taken embryos at stages corresponding only to the two middle

groups of the preceding series. In this series were studied 34 cases. Table 2 shows the distribution of the material according to groups.

Table 2

Stage of donor	Number of «successful» operations	Number of cases of induction	% of induction	Formation of additional ear vesicles	Only enlargement of the right labyrinth
Neurula before closing of medullary tube	7	4	57	4	—
Neurula with closed medullary tube . .	12	9	75	7	2

In the first group, the induced ear vesicles are somewhat smaller in size than the labyrinth of the host. The walls of the vesicles consist of cubic epithelium, which acquires the appearance of cylindrical epithelium in the neuro-epithelial spot. In the second group, there is no uniformity in the structure of the induced ear vesicles. As to their structure, part of the vesicles approach the labyrinths of the recipient. Another part has the appearance of distended vesicles with walls made up of flat epithelium. No clean-cut difference war found either in the groups studied with respect to the possibility of induction, or with respect to further development of the vesicles induced.

c) Transplantation of the Rudiment of Medulla Oblongata in Embryos of *Bombinator igneus*. In this series were studied 31 cases. The results are tabulated according to the principle as the preceding ones. Table 3 shows the frequency of induction in the two groups studied in this series.

Table 3

Stage of donor	Number of «successful» operations	Number of cases of induction	% of induction	Formation of additional ear vesicles	Only enlargement of right labyrinth
Neurula before closing of medullary tube	13	7	54	4	3
Neurula with closed medullary tube . .	7	4	57	3	1

The induction in both groups showed no quantitative differences. The induced ear vesicles are backward in dimensions in both groups. The neuro-epithelial spots are of smaller size than in the control labyrinths. As a rule, there is no formation of semi-circular ducts. The structure of the ear vesicle does not depend on whether the transplant has been taken from an early gastrula, or from a late one.

In similar experiments performed on embryos of *Amblystoma mexicanum*, there is a well expressed induction only in two cases out of the 28 studied. In operations carried out on *Rana arvalis*, the inductive action of the transplant is pronounced in three cases out of 6 possible ones. In addition experiments should be mentioned dealing with the inductive properties of the spinal cord in *T. taeniatus*, *Bombinator igneus* and *Rana esculenta*.

The experiment consisted in the following: a cut-out portion of medulla oblongata was transplanted in place of the removed part of the spinal cord

rudiment of the same embryo, whereas a piece of the spinal cord rudiment was transplanted in place of the part of medulla oblongata taken. This experiment allows to ascertain the ability of the ectoderm in the region of the spinal cord to respond to the action of a normal inductor of the labyrinth and, moreover, to form an idea of the inducing capacity of the spinal cord.

d) Transplantation of the Spinal Cord Rudiment in Place of Medulla Oblongata in *T. taeniatus*. This series comprised 15 operations; of them 6 cases were studied. In two larvae, operated at stage 20, there was found induction of additional labyrinths. In both cases, the additional labyrinth is located on the right side. It lies between the eye and the normal labyrinth. The dimensions of the additional labyrinths are smaller than those of the normal ones at this stage. The walls of the induced vesicles consisted of cubic epithelium, passing on the medial wall into cylindrical epithelium.

e) Transplantation of the Spinal Cord Rudiment in Place of Medulla Oblongata in *Bombinator igneus*. In all 14 operations were made. In two larvae were discovered additional ear vesicles located near the transplant. In one of the cases the brain tube on the place of the anterior part of medulla oblongata has the structure of spinal cord. At this level is the first pair of labyrinths. In both labyrinths the neuro-epithelium thickening is poorly expressed. The medial part of the labyrinths is formed by flat epithelium. Behind these labyrinths on both sides of the caudal part of the medulla oblongata there is a second pair of labyrinths smaller in size. These vesicles are formed of cubic epithelium. In the second case of induction there is an additional ear vesicle only on the right side of the embryo. On the left side lies one labyrinth, but considerably enlarged.

In similar experiments on *Rana esculenta*, among 17 objects studied not a single case of induction phenomena was observed.

In all the series there was observed no case of induction of the ear vesicle by a transplant arising from medulla oblongata in the region of the spinal cord.

Only occasionally above the transplant was present a thickening and digit-like outgrowth of ectoderm. The results of these series confirm once more the assumption that the induction of the ear vesicles (at the stages studied) is possible only in a limited region not far from the normal labyrinth.

Conclusions: 1. The rudiment of medulla oblongata possesses the property of inducing the labyrinth. Transplantation of a part of the medulla oblongata under the ectoderm causes the formation of an additional ear vesicle. Besides, the inductive capacity is expressed in phenomena of enlargement and changes in the shape of the adjacent labyrinth of the host.

2. For the induction of the ear vesicle to occur, a definite state of the ectoderm is necessary, which is connected with the regional position of the latter.

3. Changes in the inductive power of medulla oblongata occur parallel with the development of the medullary tube.

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DEVELOPMENT MECHANICS

DIFFERENCE IN THE RATE OF REGENERATION OF LIMBS IN THE AXOLOTL AND AMBLYSTOMA AS INFLUENCED BY EXCHANGE TRANSPLANTATIONS OF THE SKIN

By R. J. BRAGINSKAJA

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Regenerative potencies of animals are closely connected with definite stages of ontogenesis. In most of the animals the ability for regeneration is much wider and in particular the rate of regeneration of organs and of tissues is higher in the larval stages than it is in the adult state. Undoubtedly, on a par with the general influence of the organism as a whole, the properties of separate organs and tissues are also reflected upon the regenerative ability. It may be assumed that the skin's behaviour is also different in this relation at various stages of individual development. A number of authors consider the part of the skin in the process of regeneration to be very important, the skin serving as one of the sources of cell material used for the building up of the regenerative blastema. Without entering into discussion as to the elements of the skin which practically participate in the formation of the regenerative blastema, and as to the degree of this participation, it should be admitted that the cutaneous tissues really furnish material for the regenerate ([1],[2],[3]).

Supplying material for the blastema, the skin must also influence in one way or another the rate of development of the regenerate.

When we compare the sharp difference between the axolotl and the amblystoma as regards the rate of regeneration of the limbs, with the very considerable differences in the structure of their skin, it is quite natural to admit that the alterations having occurred in the skin during metamorphosis must play no small part in the retarding of the regenerative processes in the amblystoma.

The present communication relates to the study of the internal factors, which determine a slower course of regenerative processes in the amblystoma (an animal having metamorphosed) as compared with the axolotl (neotonic form); it deals chiefly with the inhibiting action of the skin of amblystoma.

As experimental animals served white and black axolotls and amblystomas (*Amblystoma mexicana*) at the age from six months to one year. Each animal was kept in a separate vessel containing water. As food served live larvae of *Chironomidae*.

The amblystomas were secured under the action of thyroidine (injection or adding powder to the water). For injection was used a 50% solution of commercial thyroidine prepared with a physiological solution. One tablet of 0.3 g per 1 l of water was used to obtain the suspension.

In summer, the symptoms of metamorphosis appeared 10 to 15 days after injection, and 25 to 30 days later when kept in suspension (depending on individual peculiarities of the animal). Complete metamorphosis was arrived at in 45 days. After completion of metamorphosis, the amblystomas secured in this way were transferred for some time into a terrarium. They were quite well, viable, actively moved about and readily devoured food.

Exchange transplantations of the skin were performed under narcosis (sulphuric ether). In all cases the operations were performed on the left hind limb. A circular incision of the skin was first made with scissors around the hip; the skin was then prepared, and turned over in such a way that the distal end of the limb was covered with a double layer of skin. Such a prepaparation of the limb for further manipulations was performed on two animals simultaneously. After this, the distal end was cut off, and the cutaneous sleeve separated was put on the naked end of the partner's limb. The previous dorsoventral orientation of the transplanted cuff was maintained. After that, the foot was amputated at the boundary line where the cutaneous sleeve begins. The second transplantation was also performed in the same way, the animal which had been the donor in the former case was now used as host. In order to prevent the falling off of the transplanted cutaneous cuff the operated animal was not immediately placed into water, but it was kept for 15 to 20 min. on the operation table. This period of time was quite sufficient to thoroughly heal the graft in the future.

During the period of time from May 23 till June 4, 1937, the following three sets of exchange transplantations were carried out.

1st set. Transplantation of skin from an axolotl on to another axolotl (control)—20 experiments (of them 12 completed).

2nd set. Transplantation of skin from an amblystoma on to an axolotl—30 experiments (25 of them completed).

3rd set. Transplantation of skin from an axolotl on to an amblystoma—30 experiments (all amblystomas perished of saprolegnia).

After healing of the transplanted skin, on June 19, all animals in all three series had the distal end of the stump amputated, care being taken that in all cases a border of transplanted skin, 2 to 3 mm wide, should be preserved.

In October all the experiments were reproduced.

1st set. Transplantation of skin from an axolotl to another axolotl (Ax. → Ax.) (control) — 30 experiments (15 of them completed).

2nd set. Amblystoma→axolotl (Ambl.→Ax.)—40 experiments (32 of them completed).

3rd set. Axolotl→amblystoma (Ax.→Ambl.)—40 experiments (11 of them completed).

4th set. Amblystoma→amblystoma (Ambl.→Ambl.) (control)—30 experiments (11 of them completed).

Amputations were carried out in these sets on October 26.

It should be noted that in the process of experimentation we came across the fact of a comparatively rapid change of the graft, which obscured the picture of the experiments and hampered the analysis of the results obtained. About 10 days later the graft began to resemble the host's skin, irrespective of the direction the transplantation was performed in, from a larva to a metamorphosed animal, or contrariwise. The changes in the skin of the axolotl transplanted on to an amblystoma were seen more distinctly. In the majority of cases after six weeks the transplanted skin differed in nothing whatever from the neighbouring one. We were unable to find out how this change occurred, whether it was by way of metamorphosis of the transplanted tissues, or else by means of their gradual substitution by the tissues of the host. As in some cases the transplantations were performed between animals of

different colouring (from black to white ones, and the contrary), it was possible to conclude by the preservation of the pigmentation of the graft that gradual substitution occurred only in a negligible degree if at all. At any rate, the first phases of regeneration proceeded under the conditions of an interaction of the underlying parts of the stump with the foreign skin, i. e. with a younger, or an older one, depending on the character of the transplantation.

The results of the experiments of the first two sets, i. e. with transplantation of skin from an axolotl to another axolotl and from an amblystoma to an axolotl, carried out in June-July, are represented in Tables 1 and 2. From the comparison of these two tables, we see that the regeneration of the limb in the first set proceeds much more rapidly than in the second one*.

Table 1

Transplantation of Skin from an Axolotl on to Another Axolotl (Ax.→Ax.) (limb amputated 19.VI)

Stage of regeneration	Time elapsed after amputation					
	10 days		20 days		30 days	
	Number of specimens	%	Number of specimens	%	Number of specimens	%
I	—	—	—	—	—	—
II	6	50	—	—	—	—
III	6	50	6	50	—	—
IV	—	—	6	50	1	8.4
V	—	—	—	—	11	91.6

Table 2

Transplantation of Skin from an Amblystoma on to an Axolotl (Ambl. → Ax.) (limb amputated 19.VI)

Stage of regeneration	Time elapsed after amputation									
	10 days		20 days		30 days		35 days		40 days	
	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%
I	15	60	2	8	—	—	—	—	—	—
II	10	40	9	36	4	16	—	—	—	—
III	—	—	12	48	12	48	10	40	—	—
IV	—	—	2	8	8	32	10	40	3	12
V	—	—	—	—	1	4	5	20	22	88

Both season of the year and temperature have, certainly, an influence on the rate of regeneration. If we compare the set of experiments made in summer with the autumn sets which continued from October until November and December, we observe a striking difference. In the first set (amputation 9. VI) after 30 days 91% of the regenerates are at the stage V and not one at a stage lower than IV.

* Determination of stages was done according to the division into five stages of regenerates of the limb of an axolotl from a bud to differentiated digits described by Kabak(4).

Table 3

Transplantations of Skin from an Axolotl on to an Axolotl (Ax. → Ax.) (limb amputated 26.X)

Stage of regeneration	Time elapsed after amputation											
	10 days		20 days		30 days		40 days		45 days		50 days	
	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%
I	14	93.3	10	66.6	5	33.3	—	—	—	—	—	—
II	1	6.7	5	33.3	5	33.3	4	26.6	—	—	—	—
III	—	—	—	—	5	33.3	10	66.7	6	40	3	20
IV	—	—	—	—	—	—	1	6.7	7	46.7	4	26.7
V	—	—	—	—	—	—	—	—	2	13.3	8	53.3

Table 4

Transplantations of Skin from an Amblystoma on to an Axolotl (Ambl. → Ax.) (limb amputated 26.X)

Stage of regeneration	Time elapsed after amputation											
	10 days		20 days		30 days		40 days		45 days		50 days	
	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%
I	32	100	30	93.7	19	59.3	10	31.2	7	21.9	5	15.8
II	—	—	2	6.3	12	37.5	20	62.5	17	53.1	11	34.2
III	—	—	—	—	1	3.2	2	6.3	8	25.0	13	40.5
IV	—	—	—	—	—	—	—	—	—	—	3	9.5

Table 5

Transplantation of Skin from an Axolotl on to an Amblystoma (Ax. → Ambl.) (limb amputated 26.X)

Stage of regeneration	Time elapsed after amputation											
	10 days		20 days		25 days		30 days		35 days		40 days	
	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%
I	11	100	11	100	11	100	10	90.9	10	90.9	10	90.9
II	—	—	—	—	—	—	1	9.1	1	9.1	1	9.1

Table 6

Transplantation of Skin from an Amblystoma on to an Amblystoma (Ambl.—Ambl.) (limb amputated 26.X)

Stage of regeneration	Time elapsed after amputation											
	10 days		20 days		25 days		30 days		35 days		40 days	
	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%	Numb. of spec.	%
I	11	100	11	100	11	100	11	100	10	90.9	80	72.7
II	—	—	—	—	—	—	—	—	1	9.1	3	27.3

In a corresponding set, where amputation was carried out on October 26, after 30 days none of the regenerates has even reached the IV stage. Summer and autumn experiments should therefore be examined separately. Nevertheless, their results are synonymous.

The results of experiments of the repeated sets performed in the autumn are represented in Tables 3, 4, 5 and 6.

Let us compare sets Ax.→Ax. and Ambl.→Ax. (Tables 3 and 4). After a month, the first set contains already a third of the animals at stage III, whereas the second is yet nearly entirely at the stages I and II. After 50 days in the majority of cases the first group goes through stage V at the time when, in the second group, only a few regenerates reach the IV stage and the large majority is still at the III and II stages.

If we make this comparison to embrace also sets Ax.→Ambl. and Ambl.—Ambl., then there becomes obvious a still more marked retarding in the latter. In both sets regeneration goes on much slowlier than even in Ambl.→Ax. (Tables 5 and 6).

The limb of an amblystoma with the skin of an axolotl regenerates, approximately, at the same rate, as the stump, which entirely consists of tissues of the amblystoma. No speeding up of regeneration occurs under the influence of the larval skin. This may be explained by the fact that the skin of the axolotl after transplantation on to the limb of an amblystoma metamorphoses very rapidly and becomes similar to the skin of the host. On the other hand, in the case of transplantation from an amblystoma on to an axolotl, the skin already metamorphosed obviously inhibits regeneration (Tables 1 and 2, 3 and 4).

Yet, under the infleunce of the transplant, the retardation is not so strong as to reduce the rate of larval regeneration to that of regeneration in an adult animal (compare Tables 3 and 4). On the contrary, the speed of the process in the given experiment is largely dependent on the ontogenetic stage of the host. Thus, as should be expected, the weakening of the regenerative ability during metamorphosis of the organism cannot be entirely put down to the differentiation of the skin.

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DEVELOPMENT MECHANICS

INDUCTIVE ACTION OF MEDULLA OBLONGATA OF THE BODY EPITHELIUM OF AMPHIBIAE

By R. E. KOGAN

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It is assumed by all research workers studying the problems bound with the determination of the organ of hearing, that the auditive vesicles are dependent formations, that they are formed from the epithelium, evidently under the inductive influence of the rudiments of other organs (Spemann, Holtfreter, Dalcq, Mantold, Schmidt, Sidorov, Lopashev).

It can be considered as established that beginning with the stage of closed nerve cords the inductive influences in the head of the embryo acquire a wide prevalence ([12],[8],[9],[10],[5]).

We have as yet no precise information as to where these inductive centres are located, or where lies the region of the inductive influences at the earlier stages, at the stages of the medium and late neurula, when the auditive vesicles are already partly determinated, thus the way these influences are propagated at this stage, and what is their nature, still remain obscure.

Stone ([11]) in a summary note points to that if one grafts the part of the amphibian's neural plate, which corresponds to the rudiment of the medulla oblongata, into the animal's side, an imperfect auditive vesicle is induced together with the auditive ganglion.

A number of authors ([3],[4], [10]) indicate that the medulla oblongata is a possible inductor of the auditive vesicle. Some believe that the auditive vesicles are induced not from one, but from several centres, that besides the medulla oblongata, the mesoderm lining the brain ([2]), the tegument of the primary intestine, including the mesentoderm ([1]) and the nervous comb ([3]), possess an inductive capacity.

A direct attempt was made in the present study to test the ability of the medulla oblongata to induce the formation of auditive vesicles by means of grafting the medulla oblongata of one embryo under the ventral epithelium of another. The experiments were started in 1936 in the Laboratory of Development Mechanics of the All-Union Institute of Experimental Medicine on the suggestion and under the guidance of G. A. Schmidt, and continued at the Institute of Experimental Morphogenesis under the guidance of D. P. Filatov.

Grafts of the medulla oblongata for the purpose of obtaining induced auditive vesicles were made by Albaum and Nestler ([1]). However, unlike our experiments, they grafted the medulla oblongata under the epithelium of another embryo mainly at the level of the medulla oblongata of the host.

In their experiments the induced auditive vesicles were situated at the level of the auditive vesicles of the host, somewhat more ventrally or behind them. It seemed possible that in these experiments the auditive vesicles induced by the grafted medulla oblongata suffered additional regional inductive influences, proper to the capital region of the embryo.

In our experiments the medulla oblongata was grafted on the abdomen or on the side of the embryo. The induced auditive vesicles arose as the result of the influence on the epithelium issuing from the grafted bit of the nervous system alone.

At first the experiments were made by the xeno- and heteroplastic method. As recipient we used *Triton taeniatus*, as donors—*Rana esculenta*, *Bombina bombina* and axolotl.

Xeno- and heteroplastics was used for eliminating in the study of the preparations every doubt as to the eventual transferring together with the explant of the rudiment of the auditive vesicle of the donor. However, it was found that in 170 grafts of carefully cleansed of foreign cellular elements medulla oblongata, in no case was there an importation of the donor's auditive vesicle. Homoplastic experiments were conducted on axolotls.

We took the medulla oblongata from embryos at the atage of fused nervous cords and grafted them into epithelial pockets of triton embryos at different stages of their development, from the stage of late gastrula to those of various ages of the neurula. Some authors regard the nerve band as one of the possible inductors of the auditive vesicles, therefore, for greater accuracy of the experiment the implant was cleansed with particular care of the rudiment of the nerve band.

It was found that the induction of the auditive vesicle from the trunk epithelium is achieved with difficulty already at the stage of the early neurula and never takes place at the later stages. The most favourable and convenient stages for these operations were the stage of the spinal furrow and the stage of the pigmented neural plate, when the future neural plate is already well distinguishable by its colour from the surrounding tissues, while the nervous cords are as yet absent.

One must think that the epithelium is subjected to the inducing action not at the moment of the operation, but somewhat later. Thus, if the operation was made at the stage of the neural plate (absence of neural cords), the inducing action was exercised at the stage of the early neurula.

The present study showed that the trunk epithelium of the triton at the stage of gastrula (the cords are as yet absent) is able to respond to the inductive influence of the medulla oblongata by the formation of auditive vesicles. If we assume that in the triton the time of the determination of the auditive vesicle coincides with the time of its determination in the amblystoma ([6]) of *Rana temporaria* and of *Bufo bufo* ([7]), then consequently by the moment of determination the trunk epitheluim of the triton loses the ability to form auditive vesicles.

Under the inductive influence of the medulla oblongata of *Rana esculenta* and *Bombina bombina*, well formed auditive vesicles arise out of the epithelium of the triton's thorax, which differ in nothing from normal vesicles at early stages. In some cases they adhere closely to the epithelium, sometimes an unbroken bond between the induced vesicles and the epithelium is visible; in other cases they have already lost this bond and lie freely between the epithelium and the implanted medulla oblongata. Sometimes as the result of induction there arise out of the epithelium defective formations in the shape of extremely small vesicles, of small epithelial thickenings, accumulations of nuclei etc. The tissues of the frogs and of *Bombina bombina*, when the embryos are stained with boric carmine, can be easily distinguished

from those of the triton both by their colour and by the size of the nuclei. The embryos were fixed on the 4—5th day after the operation, when the larvae already swam well and their tails were bordered by a fin trimming. It should be noted that the induced vesicles were always at an earlier stage of development than the auditive vesicles of the host.

In homoplastic grafts on axolotls in none of the 60 registered cases could we observe the formation of auditive vesicles out of the trunk epithelium under the inductive influence of the transplanted medulla oblongata.

To test the inductive capacity of the axolotl's medulla oblongata, the brain of the latter was implanted under the epithelium of the triton, since from our preceding experiments it followed that the triton's epithelium is able to form auditive vesicles under the inductive action of the brain of *Rana esculenta* and *Bombina bombina*. It was found that in this case also, under the influence of the transplant, the formation of the auditive vesicles is as possible as in the preceding series of experiments. It is just in this series of experiments that we observed the formation of auditive vesicles which differed from the normal auditive vesicles at early stages of development neither in their shape, nor in their locations relatively to the implanted medulla oblongata.

Consequently, the medulla oblongata of the axolotl possesses an inductive capacity similar to that of the medulla oblongata of *Bombina bombina* and of *Rana esculenta*. Under the influence of the medulla oblongata of the axolotl, the gastric epithelium of the gastrula, of the stages of the nervous furrow and of the neural plate of the triton, is able to form auditive vesicles.

Evidently, the trunk epithelium of the axolotl at these stages, owing to its apparently specific properties, is unable to respond to the action of the medulla oblongata by the formation of auditive vesicles.

The experiments described above do not solve the question, whether the action of the medulla oblongata on the epithelium is specific, i. e. whether the epithelium responds by the formation of auditive vesicles only to the action of the medulla oblongata or to that of any section of the neural tube.

In several cases we transplanted the bit of the neural tube which lies anterior to the rudiment of the auditive vesicle and corresponds approximately to the mid-brain, i. e. the bit of the nervous system lying between the rudiments of the auditive vesicles and the rudiments of the eyes was cut out. This section of the nervous tube induced the formation of auditive vesicles similary to the medulla oblongata. However, it is not possible to conjecture from these experiments that the mid-brain possesses an inductive capacity identical to that of medulla oblongata. In our experiments the donor was always at the stage of fused nerve cords, and at this stage there is as yet no clear limit between the mid-brain and the medulla oblongata; therefore it is quite probable that in cutting out the mid-brain some part of the medulla oblongata was also cut out.

This last mentioned circumstance may serve as a ground for the conclusion that in a cutting out the medulla oblongata parts of the adjacent section of the neural tube might also be cut out and transplanted together with it. The idea arises, may be conditions were created on the host's trunk at the site of the implant, which corresponded to the regionality of the head of the embryo? However, the preparations show that in most of the cases the implant developed at the site of the graft only into a well formed medulla oblongata.

The doubt may also arise, whether all the vesicles induced are identical with auditive vesicles. May be, they are merely indifferent vesicles which form owing to the property of the epithelium to produce epithelial invaginations, pearls etc. Without deciding hastily the question as to their qualitative characteristics (the answer to this question may possibly be provided

by our later experiments), it seems desirable to note the perfectly regular formation of these vesicles only under the influence of the implant and their perfect similarity to normal auditive vesicles at early development stages, soon after their separation from the epithelium.

All the facts described above permit of drawing the conclusion that the medulla oblongata of *Rana esculenta*, *Bombina bombina* and the axolotl at the stage of fused neural cords possesses (possibly, alongside of other rudiments) the capacity to induce the formation of the initial stages of auditive vesicles from the ventral epithelium of the triton's gastrula at the stages of the nerve furrow and neural plate.

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ANIMAL EMBRYOLOGY

CHANGES IN LENS-FORMING PROPERTIES OF THE BODY EPITHELIUM CONNECTED WITH THE AGE IN *RANA TEMPORARIA* AND *RANA ESCULENTA*

By N. A. MANUILOVA

(Communicated by I. I. Schmalhausen, Member of the Academy, 9. III. 1939)

Experiments on eye, especially investigation of the lens-forming properties of the epithelium, have demonstrated the importance of the comparative experimental method for studying the process of determination. The first experiments by Spemann (1) on extirpation of the eye material of the neurula were made only in *Rana fusca*; they have shown beyond question that the lens develops dependently in this species, but led at the same time to an erroneous extention of this conclusion to all vertebrata. Observations of other authors (2,3) as well as further experiments by the same writer (4), made this time on other amphibia, have shown that even in closely related species there exists variation in the degree of dependence between the formation of the lens-rudiment and eye material. Investigation of the lens-forming power of the body epithelium in amphibia has similarly shown that it possesses specifity. The comparative method, however, should not merely consist in extending investigation over a greater variety of material; comparative study of a given process at different stages of development is of no lesser significance than extending investigation on various objects.

Numerous transplantations of the optic vesicle under the body epithelium or, vice versa, of the body epithelium on the eye, have demonstrated its ability of being transferred into the lens in various amphibia. Thus, for instance, while in *Rana temporaria* the body epithelium, when brought into contact with the optic vesicle, as a rule develops into a lens, in *Rana esculenta* this potency of the body epithelium is considerably less, being totally absent in *Bufo viridis*. The question arises as to whether such striking specifity actually exists, or differences in epithelia depend on different age changes leading to identical lens-forming power of epithelia at different stages in different species; identical stages may, therefore, be strongly different in different organisms. To answer this question, the properties of the epithelium should be tried at different developmental stages, at least in two species differing in lens-forming power of their epithelia. In case the latter of the two suppositions be correct, the aspects of the lens-formation at different stages should be similar in these species, while stages equivalent in this respect should be ontogenetically different.

I have begun the work on late stages; the earlier stages—the ectoderm of the gastrula—were studied in great detail by A. P. Sheina (yet unpublished).

I am indebted to this investigator for the kind permission to quote below her data.

My experiments were conducted on embryos of *Rana temporaria* and *Rana esculenta* from the vicinity of Moscow. In *R. temporaria* the properties of the body epithelium were studied by means of transplantation of the optic vesicle under the body epithelium at the following two stages: at the first of them the tail rudiment assumes the appearance of a fin, the gills are represented by two outgrowths. The embryos, while still in membranes, begin to move. The rudiment of the lens appears as a polysticheous thickening. At the second stage the tadpoles hatch. The gills are well branched. The lens is already separated from the epithelium and represents a hollow vesicle.

In *R. esculenta* I was limited to earlier stages, since in this species, even at the stage of the tail-bud, the lens is formed of the body epithelium not as regularly as in *R. temporaria* (5). I have studied, therefore, the early and the late tail-bud stages. At the former the tail-bud appears. The eye rudiment appears in section to be a hollow vesicle. In the prospective lens epithelium no changes are observed. At the latter stage the tail-bud is elongated, the gill tubercle is separated into lobes. The lens-rudiment is represented by a thickening of the epithelium. The operation consisted in thansplantation of a portion of the body epithelium on the optic vesicle in place of the lens epitheliun which was previously removed.

Thus, in all the series, both in *R. temporaria* and in *R. esculenta*, different stages of the body epithelium were tested by the optic vesicle belonging to the early tail-bud stage.

Results of the Experiments. Altogether 75 operations were performed on embryos of *R. temporaria* at both stages; 51 of them were studied on sections; in the rest the transplantate was lost. From 25 embryos operated at the former of the stages mentioned, the optic vesicle has developed into a cup in 20; however, rudiments of the lens were formed only in three of them, the rest showing no changes in the epithelium. The cavity of the cup was filled in three of them with mesenchyma cells. The lens rudiments formed two days following operation were represented by small vesicles still connected with the epithelium. Usually, however, when the optic vesicle is transplanted under the body epithelium of the tail-bud, the lens anlage is on the 2nd day following operation larger, always separated from the epithelium, and a thickening for the formation of the fibrillar part is indicated in it.

At a more advanced stage 26 embryos were studied. The proportion of well developed cups was here lower than at the preceding stage. This should be explained by the fact that the later the stage of epithelium, the higher the difficulty of transplanting tissue under it and the easier may the transplantate be damaged. Out of the 16 embryos with well developed cups only in four rudiments of the lens were observed; in two of them the latter could not develop beyond the thickening of the epithelium, in others they represented very small vesicles. About the same results as at the preceding stage were obtained at this one. When these results are compared with those obtained from similar transplants at the tail-bud stage, one is easily convinced that the lens-forming power of the body epithelium changes with the age; at late stages, first, the lens is rarely formed, even when the cup is well developed, and secondly, lenses which are formed develop deficiently.

In *R. esculenta* 50 embryos were studied at both stages. The optic cups were developed in all of them in the same manner as on the non-operated side. At the stage of the early tail-bud 36 embryos were operated; lens rudiments were formed in all of them, and in 11 the lenses were developed like on the non-operated side and were at the stage of formation of the fibrillar

part. In the rest the lens rudiments have not developed beyond the stage of small vesicles, and in some they even represented mere thickenings of the epithelium. These results are similar to those obtained by Gosteeva ([5]) in her studies of the body epithelium of *R. esculenta* by transplanting the eye vesicle under the body epithelium. She has observed, it is true, aside from defective rudiments, instances of complete absence of the latter, while the optic cup was well formed. The formation of the lens from the body epithelium of the late tail-bud is hindered to a great extent; only in three embryos a small thickening of the epithelium was observed, in spite of the fact that fixation was done within the three-day period. In three embryos the lens was formed at the edge of the optic cup, while in the rest no changes in the epithelium were observed, in spite of the regular development of the optic cup. It is of interest that such a low proportion of formation of lens rudiments and their defective development were also found in *R. temporaria*, but at a more advanced stage, when the tadpoles had already hatched. It is obvious that the results obtained in *R. esculenta* at the stage of early tail-bud should have been secured in *R. temporaria* at a somewhat earlier stage than the earliest one of those studied here.

At early developmental stages in *R. temporaria* and *R. esculenta* a similar response of the body epithelium to the action of the optic cup is observed; an earlier stage of the one species, late tail-bud of *R. esculenta*, corresponds to a later stage of the other species—the hatching stage of *R. temporaria*. We may conclude from this that the decrease in the lens-forming power of the body epithelium with the age proceeds with different velocity in different species, and this very fact determines the existing specific differences.

Such a conclusion is still better supported by experiments by A. P. Sheina who studied the lens-forming power of ectoderm and showed that ectoderm of the gastrula in all the species studied by her, *R. temporaria* and *R. esculenta* included, equally well produces the lens, when brought into contact with the optic vesicle. The gastrula thus proved to be a stage, at which the prospective ventral epithelium in all the amphibians studied yet develop into a lens, independently of its specific origin. Only later and obviously after the gastrula stage its age changes begin; the latter develop with different velocity in different species and lead to the fact that as early as at the tail-bud stage the lens-forming power of the epithelium appears to be different. Therefore, when isolated developmental stages (most commonly the tail-bud stage, at which the lens-forming power of the epithelium is always studied) were studied, a conclusion was arrived at that lens-forming power of the body epithelium is different in different species. As a matter of fact, however, the lens proved to be equally capable of development at an early stage in various amphibians, and further aspects of lens-formation were similar in these organisms, but there was no correspondence of stages. One should, therefore, make special reference to the stage, while discussing lens-forming power of the epithelium of a given species.

These experiments which demonstrate age changes in the lens-forming power of the body epithelium are in no agreement with those, where the properties of epithelium transplanted into the cavity of the optic cup were studied ([6]); they have shown that in all the amphibians the body epithelium develops into a complete lens even at later stages. Divergence is caused by different technique. In the above-described experiments were studied properties of the epithelium which was left in its normal position, i. e. in contact with the rest of the integuments of the animal; on the other hand, when portions of the epithelium are transplanted into the cavity of the cup, the epithelium is isolated from the system as a whole. Data of the two series of experiments are correct; it is beyond question that, first, the properties

of the epithelium change with the age, and secondly, transformation of the epithelium into the lens is facilitated when epithelium is isolated from the system as a whole. The latter circumstance is of decisive importance for the result of the experiment, since the contact of the epithelium with the eye is preserved, while its absence would lead to weakening of the lens-formation; in all the experimental series the late epithelium is brought into contact with the optic vesicle. Cases when the influence of the eye rudiment prior to invagination proves to be insufficient, similarly point to the weakening of the lens-forming power of the epithelium with the age, since such a contact of the vesicle with epithelium is sufficient at early stages for the development of a well formed lens.

In concluding it may be said that only a comparative study of the lens-forming power of the body epithelium in *R. esculenta* and *R. temporaria* at different stages allowed to draw the conclusion that the body epithelium of these species possess different lens-forming power and that a change in these properties during development proceeds with different velocity.

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PALEONTOLOGY

QUATERNARY (INTERGLACIAL) FAUNA ON THE APSHERON PENINSULA

By V. V. BOGACHEV

(Communicated by A. A. Borissiak, Member of the Academy, 8. III. 1939)

For a long time finds of remains of post-Tertiary mammals have been occasionally recorded on the Apsheron peninsula. Besides two finds of teeth of *Elasmotherium* (one is reported by M. V. Pavlova), those of a rhinoceros *(Rhinoceros* aff. *merkii)*, *Equus* sp. and *Equus caballus*, *Hyaena hyaena* (var.?), *Bos primigenius*, *Cervus elaphus* and several others, mentioned by Bogachev in the local press, should be pointed out. In February, 1938, A. S. Mastansade presented to the Azerbaidjan branch of the Academy of Sciences of the USSR (AZFAN) a tooth of a cave bear, and later teeth of a hyaena, unearthed by him from kir quarried near the village Binagady. Likewise in brea-beds had been formerly recovered a tooth of an *Elasmotherium*, an *Aurochs (Bos primigenius)* (skull, in the vicinity of the village Digiya), two skulls of deer (Artem island), jaws of a horse, and a small metacarpal bone of a small rhinoceros (near the station Khurdalan).

During the first trip to Binagady, from the brea-beds were excavated multitudes of bones and teeth of various mammals: bear, hamster, hyaena, wolf, fox, jackal, boar, rhinoceros, horses, oxen, deer, dzeren, porcupine, hare, jerboa, several diminutive rodents, hedgehog, tortoise (terrestrial), rostrums, claws and bones of a griffin, barnacles, ducks, cormorants, herons, snipes, gulls; a great number of various aquatic and land beetles; roots, stems, seeds, shoots of various plants.

The trouvaille attracted attention, and AZFAN charged a party from its Museum of Natural History to carry out excavations. Work was started at the beginning of December, and new rich material was collected.

Among remains of mammals was found a jaw of an old large hedgehog, apparently, *Erinaceus rumanicus transcaucasicus* Satun. Of carnivores, most abundant are remains of jackals (*Thos aureus* L.), old as well as young ones. Remains (jaws) of foxes are not uncommon. They have not been treated yet. One jaw recalls an arctic fox (*Alopex lagopus* L.), though the possibility of its penetration into the Apsheron is dubious.

A few specimens of hyaena have been obtained, for the most part, remains of skulls of young animals with a second dentition. One skull is of conspicuous size, otherwise not any different from a Transcaucasian hyaena. However, there is one more skull, rather shortened, broad and elevated, with a wider brain case than in a Transcaucasian hyaena of the same size, more powerful teeth pm_2, pm_3, pm_4, but pm_1 with even no alveolus preserved,

though it is a young animal yet with milk dentition just replaced. All the other hyaenas may be fully identified with *Hyaena hyaena* L., whereas the above-mentioned skull belongs to a separate variety.

There are fragments of a skull of a young cave bear and a molar of the upper jaw, just cut and not yet functional. The skull of a young hamster was found, however, with teeth already replaced (almost full cut). This hamster, evidently, presents a separate species, *Meles* n. sp., though in general coming quite close to *Meles meles* (*M. taxus* auct.), closer than to *M. arenarius* of the Caspian (Kalmuck) steppes. As compared with the endemic Caucasian *Meles urartorum* Satun. of the Bronze age, it shows marked distinction in dentition.

Small carnivores (apparently, weasels?) are represented by negligible remains.

Remains of equidae are particularly abundant. They partly belong to *Equus caballus* L., however, in part evidently approaching *Asinus onager*. A large number of jaws belong to foal from 1.5 months onwards, and one find may be even recognized as a mature foetus.

The rhinoceros find is very characteristic. In the Binagady area were found remains of four rhinoceroses, one a young individual, at the age of replacement of milk dentition, one—somewhat older, one—very old with teeth practically worn away. Among its skeletal bones were found those of a young one with milk teeth, already slightly abraded.

The study of the teeth, skulls, extremities leads to the conclusion that we are dealing here with no *Rhinoceros merkii*, neither with *Rhinoceros tichorhinus* for that matter, since the internarial septum has not yet attained full development. Our specimens are rather suggestive of the species *Rh. hemitoechus*. Possibly, in Transcaucasia had lived a particular race, though this assumption is in want of additional support, in view of the rather extensive geographical range of *Rh. merkii* and *Rh. tichorhinus*.

There were unearthed some remains of a wild boar (*Sus croja* fer.) of a mature individual (female), as well as of young pigs. The deer (*Cervus elaphus*) is represented by a few specimens—both very young and adult forms. There are fragments of horns. Further mention should be made of the recovery of skeletal remains of a dzeren—*Gazella subgutturosa* Güld. Remains of *Bos primigenius* Boj. belong to a large sized variety, as well as to rather diminutive forms, which have not been yet studied in more detail.

The absence of the camel deserves mention.

As to rodents, a not infrequent occurrence of remains of a porcupine should be noted, as distinguished by certain primitiveness of molars from the Transcaucasian *Hystrix hirsutorostris*. There are scarce remains of a hare (*Lepus* sp.). A scant number of bones belong to a jerboa (*Allactaga* sp.); frequently occur jaws of various minor rodents.

Moreover, remains of a land tortoise should be mentioned.

Great multitudes of bird remains still await development. Remains of beetles are of especial interest. From the first collections, A. V. Bogachev has determined a quantitatively abundant, though rather uniform fauna. Collections during the second half of 1938 comprise twice the amount of specimens enumerated in the first list, by adding to it representatives of dung beetles, lady-birds and others; there is a particular increase of the list of forms no more existent on the Apsheron peninsula today. The first list comprises (spring of 1938): *Sphodrus* (*Lychifugus*) *cellarum* Ad., *Acinopus laevigatus* Motsch., *Hydrous piceus* L., *Hydrophilus profanifuga* Sem., *Cybister latemarginatus* Deg., *Dytiscus dimidiatus* Bergstr., *Colymbetes* sp., *Gyrinus colymbus* Er., *Thanatophilus rugosus* L., *Necrobius rufipes* Deg., *Sphenoptera glabrata* Mér., *Adesmia fischeri* Fald., *Tentyria tessulata*

Tausch., *Pachyscelis clavaria* Mén., *Blaps pterotapha* Mén., *Gonocephalum pusillum* F., *Psallidium maxillosum* F., *Donacia gracilicornis* Jak.

Most of the above-mentioned forms are dwelling on the Apsheron peninsula, under its semi-desert conditions, but there is no room for the development of aquatic forms. However, on the sea shore one may always meet not only fossil, but also living *Dytiscus*. Endowed with a strong power of flight, these diving beetles (*Dytiscidae*) cover in a short time vast areas. *Donacia* (leaf-beetles), being related to littoral vegetation of fresh water basins, are unknown on the Apsheron.

Some of the forms indicated in the list are considered for Caucasus as forms of Iranian origin. Now the question should be reconsidered from the viewpoint of relict faunas, and the influence of glacial periods. Though there are several indications of a very humid climate on the Apsheron during the age of formation of Binagady brea-beds, still the general aspect of the insect fauna is that of a drought tolerant one (xerophile), even semi-desert. The same applies to the flora developed by V. A. Petrov (wood, shoots, roots, rhizomes, stems, fruits, pollen), testifying to savanna landscape, i. e. to dry steppe with scattered clusters of trees.

Vegetable remains are concentrated in two layers. The one shows prevalence of sedge, canes, occurrence of horse-tail remains, in general, of littoral vegetation. The other layer contains tree trunks, fruits, remains of stems of umbellate plants *(Ferula?)*, cereal plant seeds etc.

There were found the wood and fruits of *Pyrus salicifolia* Pall., typical for semi-desert, dry tracts of land in Azerbaidjan. Juniper stems (*Juniperus polycarpos* C. Koch) are particularly abundant, and not infrequently is found its fruit. *Pistacia mutica* F. et M. (the fruit) was also met. Especially frequent are fruits of the umbellate plant *Zozimia* sp., quite similar to those of one Iranian species. Remains of *Astragalus* (*Tragacantha* sp.) were likewise found. The *Tamarix* tree was identified.

Thus, a clear picture arises of a country with rather dry climate, with a fresh water lake which supplied with drinking water great numbers of mammals. It was a mixed fauna. Alongside of pure steppe animals, such as the dzeren and jerboa, hyaena, wild ass (*Equus onager?*), occurred forest-steppe forms (*Aurochs*) and forest forms (deer). The porcupine, now dwelling in the wooded Talysh country in the Transcaspian region, lives in the semi-desert and occurs even in a true desert.

The bones are a chaotic medley. No complete skeletons were disinterred. Even such large-sized, as the skeleton of a rhinoceros, are found dismembered, the bones strongly dislocated. The bones of small birds form a peculiar mass, resembling vegetative felt with interspersed beetles.

When analyzing the described picture and comparing it with material used by Weigelt (1), Wasmund (2), as well as recalling finds in Starun (Galicia), and a perfectly analogous cemetery of vertebrate and invertebrate animals in the asphalt accumulations of Rancho La Brea, California (3), one may form the following idea of the conditions of the formation of the Binagady ossiferous brea-beds: after the retreat of the sea with *Didacna surachanica* (ancient Caspian terraces), viz. the sea, which had abraded the folding of the petroliferous productive formation, on the abraded plain, which became covered with xerophile vegetation, a fresh water, or slightly brackish, lake was formed. From the abraded strata of the productive formation oil continued to exude. Tangential stresses (posthumous orogenic movements) contributed to it, and supported the activity of mud-volcanoes on this abraded anticline. Oil spread over the surface of the lake, was blown by winds to the flat miry shores. Fluctuations of the lake level depended upon seasonal conditions, snow melting, rainfall, rainless periods, droughts, winds. The

animals assembled at the lake to drink, but it was a long way to pure water. It was necessary to pass a broad stretch of half-dried coast, the strip of oil driven ashore. Animals exhausted, weak, either too young, or too old, or enfeebled during the replacement of dentition, reached the water with difficulty, but were not strong enough to return to the firm ground. They were trapped, and perished in the oil-saturated border of the lake basin, and their carcasses attracted hosts of rapaceous beasts. Aquatic birds, especially those on the migratory flight, descended at night upon the glittering surface of the lake, or upon the oil covered shore. Having stained their wings with oil, the birds were unable to take off in flight. They became the prey of hyaenas, wolves, jackals, foxes, raptorial birds, and the bones of their disrupted carcasses sank into the oil-saturated mire of the shore, or were entombed in the bottom of the lake. The bones were trampled upon and jumbled up by droves of horses. Day by day, through ages, countless animals coming to the water were mechanically destroying the bone-bearing layer.

The geological age of this bone-bearing layer has not been definitely established yet. It may be merely stated that it is lying above the shell-beds with *Didacna surachanica*, *Didacna incrassata*, *Didacna kovalevskii*, *Dreissensia polymorpha* and others. In the opinion of A. L. Reinhardt, the terrace indicated above corresponds to the Riss-Wurm stage of the Interglacial epoch. In the latter case, the age of the ossiferous stratum should be correlated with the Wurmian glaciation.

The rhinoceros' type appears to be more ancient, hence the suggestion arises to correlate it with the Riss glaciation, accordingly shifting the terrace with *Didacna surachanica*.

It is usually agreed that the last orogenic phase on the Apsheron peninsula, the so-called Kalin phase, corresponds to the Riss glaciation. Even two phases are pointed out. The Kalin phase is prior to the deposition of beds with *Didacna surachanica*. However, beds with *Didacna surachanica* have, in their turn, been subjected to a marked dislocation.

The ultimate solution of this question should be approached with caution and careful discrimination of all recent data.

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PALEONTOLOGY

STRATIGRAPHIC VALUE OF SPIRIFERS IN SERPUKHOV BEDS OF THE LOWER CARBONIFEROUS OF THE MOSCOW BASIN

By S. V. SEMICHATOVA

(Communicated by A. A. Borissiak, Member of the Academy, 15. III. 1939)

At the present time a detailed paleontological study has been completed of groups of Spirifers having the widest distribution in the supra-coal bearing beds of the Lower Carboniferous of the Moscow basin (2). It will be timely to summarize some of the results bearing upon their stratigraphical value.

The most interesting data have been obtained in regard to the distribution of *Spiriferidae* in the Serpukhov series, in whose fauna the Spirifers play a decidedly greater rôle than in the fauna of the Oka series (Table 1) *. This table is worked out after the method employed in the recent works, dealing with the description of Brachiopods of the Moscow basin; this method enables us to introduce data on the quantitative evaluation of fossils with reference to the facial peculiarities of the fossiliferous rocks. Facies variation should receive particular attention when studying such groups of organisms which, like *Spiriferidae*, leading a fixed mode of life, were very much dependent upon facial conditions. Crinoidal marls of the known exposure near the village Luzhki are placed in Table 1 among the Steshevo beds; in literature (1) they have been regarded as belonging to the lowermost subdivision of the Serpukhov series; however, according to the whole complex of the Spirifers found over there, they come closer to the Crinoidea marls of the Steshevo beds; this is in perfect agreement with data recently obtained by T. G. Sarytcheva (private information).

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* Abbreviations used in Tables 1 and 2 denote: Soc. (sociales)—fossil occurring practically in every exposure of the given horizon, in the facies concerned. Cop. (copiosae)—fossil met in considerable numbers, but not in every exposure of the given horizon, in the facies concerned. Sp. (sparsae)—isolated specimens of the fossil occurring in many (several) exposures. Sol. (solitariae)—isolated specimens encountered in some exposures of the given facies. Un. (unicum)—fossil found in a limited number in one exposure. The occurrence of a closely related form which, owing to the state of preservation, cannot be referred with full confidence to the given species, is denoted by an asterisk.

The stratigraphic division of the Lower Carboniferous of the Moscow basin is presented in Table 1 according to the scheme accepted by Schwetzow and Jablokov in the Guide for Excursions of the International Geological Congress (Moscow Coal Basin. Int. Geol. Congress, XVII Session, 1937.)

The groups of Spirifers developed in the Lower Serpukhov series, appear in the Moscow basin during the Venev period. Rare and small-sized individuals have been met in the Venev beds both in the southern and north-western parts of the basin. In the lower beds of the Serpukhov series these groups attain at once great development. However, in the southern and north-western parts of the basin the initial moments of the Serpukhov age are represented by two different complexes of Spirifers (Table 2).

Table 2

Tarussa Time

		Southern part of the Moscow basin	North-western part of the Moscow basin
Characteristic forms	Confined exclusively to Tarussa beds	*Sp. pseudotrigonalis* sp. n., sp. *Sp. multicostatus* Schwetz., sp. *Sp. praebisulcatus* var. a, sp. et var. n., sp.	*Sp. gröberi* Schwetz. em. n. cop.
	Passing into the Steshevo beds	*Sp. praebisulcatus* sp. n., sp.	—
Accompanying forms	Confined exclusively to Tarussa beds	*Sp. sarytchewae* sp. n., un. *Sp.* aff. *multicostatus* Schwetz., un. *Spirifer* sp. I, un. *Spirifer* sp. II, cop.	—
	Passing into other beds	*Sp. gröberi* Schwetz em. n., un. *Sp. tarussaensis* sp. n., un. *Sp. serpuchoviensis* sp. n., un.	*Sp. russiensis* Schwetz., un. *Sp. botcharovensis* sp. n., un.

Peculiar to the Tarussa beds of the southern part of the basin are rich associations including *Sp. pseudotrigonalis*, *Sp. praebisulcatus*, *Sp. multicostatus*, with less frequent *Sp. praebisulcatus* var. a, single *Spirifer* sp. II and others. Most of the enumerated Spirifers have a wide horizontal range of distribution, though usually no considerable number of specimens occur at one point. Among them *Sp. multicostatus* and *Sp. praebisulcatus* var. a are restricted exclusively, or nearly so, to Tarussa beds; apart from that, *Sp. pseudotrigonalis* is met in Crinoidea limestones and Crinoidea marls of the Steshevo beds, the specimens from the crinoidal limestones and marls being distinguished by considerably smaller sizes as compared to those from the Tarussa limestones.

The Bensk horizon—lower subdivision of the Serpukhov series, north-western part—is characterized by the presence of *Sp. gröberi* with isolated representatives — *Sp. russiensis* and extremely rare *Sp. botcharovensis*.

The deposits of the southern and north-western part of the basin have in common one form—*Sp. gröberi* only. It is predominant in the north-west, occurring in the south but in isolated exposures, and represented here by a small number of specimens.

The difference in the specific composition of the fauna pertaining to the lower subdivision of the Serpukhov series, of the southern and north-western parts of the basin, is linked with a difference in the general character of the Spirifer complex. In the south the Spirifer fauna of the Tarussa time

bears all the characters of a luxuriant fauna developing in situ. This is substantiated by the rich variety of species and the existence of numerous transitional forms, linking separate species together. Even such forms, the chief development of which refers to a later geological time, appear during the Tarussa time in the southern part of the basin (Table 1). On the contrary, the Spirifer fauna of the north-western part of the region bears an oppressed nature; there is but one species pre-eminent, represented by vast numbers of uniform individuals associated with single specimens of a few other species. Such character of fauna bears witness to unfavourable conditions for the development of *Spiriferidae* in this part of the basin.

The difference between the Spirifer fauna of the Tarussa beds and of the Bensk horizon should be accounted for. First of all, the question arises whether it is correct to consider them parallel; however, the superposition upon both of them of Steshevo strata with fossils as characteristic as *Sp. gamma* is quite in agreement with their synchronous formation accepted by stratigraphers. Moreover, in the Steshevo time there is likewise observed as sharp a difference between the fauna of *Spiriferidae* of the south and north-west of the basin, in this case, obviously due, as will be further shown, to changes in the facies character of the rocks. The differences in the composition of the fauna in Tarussa and Bensk beds it would also be more safe to ascribe to the difference of facial conditions. True enough, the above-mentioned beds are represented both in the south and in the north by limestones, but differences observable between these two varieties of limestones (nature of schistosity, presence of flints, etc.) most certainly point to essentially different conditions of their sedimentation. If a detailed study of the fauna would be carried on simultaneously with as detailed a lithological investigation of the fossiliferous rocks, the solution of questions of the kind just raised would not present such difficulties.

The Steshevo beds of the Moscow basin are represented by various types of facies. The Spirifer complex in each of these types is given in Table 1.

Of the facies described in the present paper, the richest in species is the one contained in Crinoidea marls. Here are developed simultaneously (in the same outcrops) representatives of the two Spirifer groups under consideration—the group of *Sp. pseudotrigonalis* and *Sp. gröberi*. Characteristic of this facies is a varied complex with *Sp. praebisulcatus* passing thither from subjacent strata, this species occurring here in associaton with *Sp. gamma*, rare and undersized *Sp. pseudotrigonalis*, and isolated *Sp. tarussaensis* and *Sp. serpuchoviensis*.

The complex of dolomitic-marly facies of the Steshevo beds is characterized by an abundance of individuals and paucity of species. The prevalence of *Sp. botcharovensis* is characteristic, with few *Sp. gamma*, isolated specimens of *Sp. gröberi* and *Sp. botcharovensis* var. *robusta* occurring among them, and with *Sp.* aff. *botcharovensis* more numerous in some of the exposures.

In the clays of the Steshevo beds the Spirifer complex differs from that of the marly facies by still greater paucity. For all the types of facies of the Steshevo beds, excepting the Crinoidea limestones, *Sp. gamma* is a valuable index fossil. This species does not spread beyond the limits of the Steshevo beds, and shows a large horizontal distribution, occurring along the entire upper course of Volga, within the area of development of the above-named beds, as well as in all the outcrops of these beds in the southern part of the basin.

The difference between the Spirifer association in the south and north-west of the Moscow basin, observed in the Tarussa time, persists during the Steshevo time as well, being connected here with the prevalence of a dolomite-marly facies in north-west, and one of clays, Crinoidea limestones

Distribution of *Spiriferidae* in the Serpukhov Series

	Tarussa beds		
	Southern part of Moscow basin. Limestones	North-western part of Moscow basin. Limestones	Dolomitic marls
*Spirifer pseudotrigonalis** sp. n.	(Sukhoi Osetrik, Alexin, Paskhalovka, Tibeikino) sp.	—	—
Spirifer sulomaensis sp. n.	—	—	—
Spirifer multicostatus Schwetz.	(Alexin, Lanshino) sp.	—	—
Spirifer aff. *multicostatus* Schwetz.	(Alexin) un.	—	—
Spirifer praebisulcatus sp. n.	(Fomino, Tibeikino, Knyaz-Mikhailovo) sp.	—	—
Spirifer praebisulcatus var. a. sp. et var. n.	(Alexin, Tarussa, Ignatovskaya, vil. Bogorodskoye) sp.	—	—
Spirifer serpuchoviensis sp. n.	(Potapovo, Bekhovo) un.	—	—
Spirifer tarussaensis sp. n.	(Tarussa) un.	—	—
Spirifer sarytchewae sp. n.	(Alexin, Kaluga) un.	—	—
Spirifer sp. I	(Sukhoi Osetrik) un.	—	—
Spirifer sp. II	(Sukhoi Osetrik) cop.	—	—
Spirifer russiensis Schwetz.	(Bensk) sol.	—	—
Spirifer aff. russiensis Schwetz.	—	—	—
Spirifer gröberi Schwetz.		(Bensk, Sukhoi Osetrik) cop.	(Bocharovo, sp. Steshevo, Podbo-[rovye *) sp.
Spirifer gamma sp. n.		—	(Bocharovo, Steshevo) sp.[3]
Spirifer botcharovensis sp. n.		(Bensk) un.	(Bocharovo, Steshevo) soc.
Spirifer botcharovensis var. *robusta* sp. et var. n.		—	(Bocharovo) un.
Spirifer aff. *botcharovensis* sp. n.		(Sukhoi Osetrik) un.	(Bocharovo Steshevo) soc.
Anelasmina pinguisiformis sp. n.		—	—
Anelasmina pinguisiformis var. lata sp. et var. n.		—	—
Anelasmina pinguisiformis var. *trigonalis* sp. et var. n.		—	—

Notes. In this table are indicated only the main places of occurrence of the

Table 1

of the Lower Carboniferous of the Moscow Basin

Steshevo beds			Protva beds
Clays	Crinoidea limestones	Crinoidea marls	Limestones
—	(Between Anofrievka and Nikolskaya) un.	(Lujki) un.	—
—	(Between Anofrievka and Nikolskaya) cop.	—	—
—	—	(Lujki) un.	—
—	—	—	—
—	—	(Lujki, Glazechnya, pog. Piatnitza, Dukino, Zaikino) soc.	—
—	—	—	—
—	—	(Lujki) un.	—
—	—	(Lujki) un.	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
(Bordukovo) cop.	—	—	—
(Bordukovo) un. Koltzovo on the Olshanka) un.	(Toropovo, Venev, Monastery) cop.	—	—
(Bordukovo) sol.	—	(pog. Piatnitza, Glazechnya) cop.	—
(Bordukovo) un.	(Baranovo) un.*	—	—
—	—	—	—
(Bordukovo) un.	—	—	—
—	—	—	(Kremenskoye, Potresovo, Tadenka) soc.
—	—	—	(Kremenskoye) un.
—	—	—	(Kremenskoye, Tadenka, Potresovo)soc.

forms concerned.

and Crinoidea marls in the south. Like in the Tarussa time, the Spirifer fauna of the nort-west bears features of oppression.

As seen from the foregoing, the groups of *Sp. pseudotrigonalis* and *Sp. gröberi* are uniting the Tarussa and Steshevo strata in the Moscow basin; the dominance of these two groups among the *Spiriferidae* testifies to the presence in our region of one of the two strata; in the composition of the fauna of the under- and overlying beds these two groups play but a quite negligible part.

In the Protva beds is developed one group of Spirifers rather poor in species, but represented by numerous specimens; it belongs to a genus not encountered in more ancient strata of the supra-coal bearing beds of the Lower Carboniferous of the Moscow basin. This genus *Anelasmina* (*Anelasmina* Ivan. et Ivan.=*Anelasma* Ivan.) appears in the result of the evolution of the internal structure within the group of *Sp. pseudotrigonalis*, and is linked up with it through transitional forms. The gradual evolution of the *Sp. pseudotrigonalis* group in the given direction may be traced throughout the Tarussa and Steshevo times, and is indicative of close relationship between the fauna of the Protva beds and that of the remaining subdivisions of the Serpukhov series, in spite of the seeming isolation of the Protva Spirifers. Characteristic fossils of the Protva beds are *Anelasmina pinguisiformis* and *Anelasmina pinguisiformis* var. *trigonalis*.

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ERRATA

In vol. XXII, № 6, in the article by N. N. Medvedev, p. 345, line 8, for «homozygous» read «hemizygous».

21

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